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They Book is

W. Johnson

W. Johnson

Maggon (505)
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6 Sept. 28

ON THE
FRONTISPIECE and BOOK.

ALL Recreations do delight the Mind;
But these are best, being of a learned kind:
Here Art and Nature strive to give content,
In shewing many a rare Experiment:
Which you may read, and on their Schemes here look,
Both in the Frontispiece, and in the Book.
Upon whose Table new Conceits are set,
Like dainty Dishes, thereby for to wet
And win your Judgment with your Appetite
To taste them, and therein to take delight.
The Senses Objects are but dull at best,
But Art doth give the Intellect a Feast.
Come hither then, and here I will describe
What this same Table doth for you provide.
Here Questions of Arithmetick are wrought,
And hidden Secrets unto light are brought.
The like it in Geometry doth unfold,
And some too in Cosmography are told:
It divers pretty Dyals doth descry,
With strange Experiments in Astronomy,
And Navigation, with each several Picture,
In Musick, Opticks, and in Architecture:
In Statick, Machanicks, and Chymistry;
In Water-Works; and, to ascend more high,
In Fire-Works, like to Joye's Artillery.
All this I know thou in this Book shalt find,
And here's enough for to content thy Mind.
For from good Authors, this our AUTHOR drew
These Recreations, which are Strange and True:
So that this BOOK's a Centre, and 'tis fit
That in this Centre, Lines of Praise should meet.
W. S.

MATHEMATICALL
Recreations
Or a Collection of
sundrie excellent
Problemes
out of ancient & moderne
Philosophers
Both usefull and
Recreative
Printed for William Leake
and are to be sold at the
Crowne in fleet streete
betweene the two
Temple gates.

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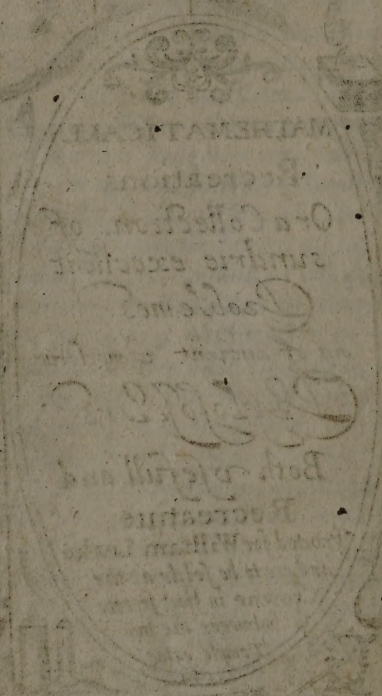
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Mathematical Recreations :

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OR,

A Collection of many

PROBLEMS

Extracted out of the

Ancient and Modern Philosophers :

A S,

SECRETS and EXPERIMENTS

I N

Arithmetick, Geometry, Cosmography, Horologio-
graphy, Astronomy, Navigation, Musick, Opticks,
Architecture, Statick, Mechanicks, Chymistry,
Water-Works, Fire-Works, &c.

Not vulgarly manifest till now.

Written first in *Greek* and *Latin*, lately compil'd in
French by *HENRY VAN ETTEN*, and now
in *English*, with the *Examinations* and *Augmenta-
tions* of divers Modern *MATHEMATICIANS*.

Whereunto is added,

The DESCRIPTION and USE

OF

The Double **HORIZONTAL DYAL**,

AND

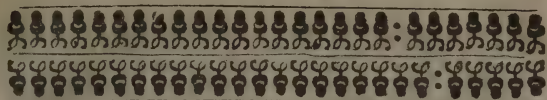
The General **HOROLOGICAL RING** :

Invented and Written by *William Oughtred*.

L O N D O N :

Printed for *William Leake*, and *John Leake*, at the Crown in
Fleetstreet, between the Two Temple-Gates. 1674.





To the Thrice Noble,
and most Generous Lord,
The Lord *Lambert Verreyken* :
Lord of *Hinden, Wolverthem, &c.*

My Honourable Lord,



Mongst the Rare and Curious Propositions which I have learned out of the Studies of the *Mathematics* in the famous University of *Pont a Mousson*, I have taken singular pleasure in certain *Problems*, no less Ingenious than Recreative, which drew me unto the search of Demonstrations more difficult and serious, some of which I have amassed, and caused to pass the *Press*, and here dedi-

The Epistle Dedicatory.

dedicate them now unto Your Honour : Not that I account them worthy of Your View, but in part to testify my affectionate desires to serve You, and to satisfy the Curious, who delight themselves in these Pleasant Studies ; knowing well that the *Nobility* and *Gentry* rather study the *Mathematical Arts* to content and satisfy their Affections in the speculation of such admirable Experiments as are extracted from them, than in hope of gain to fill their Purses. All which Studie^s, and others, with my whole Endeavours, I shall always dedicate unto Your Honour, with an ardent desire to be accounted ever,

*Your most humble and obedient
Nephew and Servant,*

H. VAN ETTEN.

To the READER.



I hath been observed by many, that sundry fine Wits, as well amongst the Ancient as Modern, have sported and delighted themselves upon several things of small consequence, as upon the Foot of a Fly, upon a Straw, upon a Point; nay upon nothing: Striving as it were to shew the Greatness of their Glory, in the Smallness of the Subject: And have amongst most solid and artificial Conclusions, composed and produced sundry Inventions both Philosophical and Mathematical, to solace the Mind, and recreate the Spirits,

a rits,

The Epistle to the Reader.

rits, which the succeeding Ages have imbraced, and from them gleaned and extracted many admirable and rare Conclusions; judging that borrowed matter often-times yields praise to the industry of its Author.

Hence for thy use (Courteous Reader) I have with great search and labour collected also and heaped up together in a body, of these pleasant and fine Experiments to stir up and delight the Affectionate, (Out of the Writings of Socrates, Plato, Aristotle, Demosthenes, Pythagoras, Democritus, Pliny, Hyparchus, Euclides, Vitruvius, Diaphantus, Pergæus, Archimedes, Papus Alexandrinus, Vitellius, Ptolomæus, Copernicus, Proclus, Muralicus, Cardanus, Valalpandus, Kepleirus, Gilbertus, Tychonius, Dureirus, Josephus, Clavius, Gallileus Maginus, Euphanus
Ty-

The Epistle to the Reader.

Tyberil, and others) knowing Art imitates Nature, that glories always in the variety of things which she produceth to satisfy the Minds of Curious Inquisitors. And though perhaps these Labours to some humerous Persons may seem vain and ridiculous, for such it was not undertaken: But for those which intentively have desired and sought after the knowledge of those things, it being an Invitation and Motive to the search of greater matters, and to imploy the Mind in Useful Knowledge, rather than to be busied in vain Pamphlets, Play-books, fruitless Legends, and prodigious Histories, that are invented out of Fancie, which abuse many Noble Spirits, dull their Wits, and alienate their thoughts from laudable and honourable Studies. In this Tractate thou maist therefore make choice of such

The Epistle to the Reader.

Mathematical Problems and Conclusions as may delight thee, which kind of Learning doth excellently adorn a man; seeing the Usefulness thereof, and the Manly Accomplishments it doth produce, is profitable and delightful for all sorts of People, who may furnish and adorn themselves with abundance of matter in that kind, to help them by way of use and discourse. And to this we have also added our Pyrotechny, knowing that Beasts have for their Object onely the surface of the Earth, but hoping that thy Spirit, which followeth the motion of Fire, will abandon the lower Elements, and cause thee to lift up thine Eyes to soar in an higher Contemplation, having so glittering a Canopy to behold, and these pleasant and recreative Fires ascending may cause thy affections also to ascend. The Whole
whereof

The Epistle to the Reader.

whereof we send forth to thee, that desirest the Scrutability of things ; Nature having furnished us with matter, thy Spirit may easily digest them, and put them finely in order, though now in disorder.



AD AUTHOREM
D. D. Henricum Van Etenium,
Alumnum Academiae
PONTA MOUSSON.

Ardua Walkeri fileant secreta profundi,
Desinat occultam carpere Porta Viam.
Itala Cardani mirata est Lampada docti
Terra, Syracusum Græcia tota senem:
Orbi terrarum, Ptolomæ: Clepsydra toti,
Rara dioptra Procli, mira fuere duo.
Anglia te foveat doctus Pont Mousson alumnum,
Quidquid natura, qui legis, hortus habet.
Dolla, coronet opus doctum, te sit tua docto
Digna, Syracusii, arca, corona, viri.
Arca Syracusii utinam sit plumbea servis,
Aurea sed Dominus, aurea tota suis.

By



By way of
ADVERTISEMENT.

*Five or six things I have thought
worthy to declare, before I pass
further.*

First, That I place not the
speculative Demonstrations with all these *Problems*, but content my
self to shew them as at the Fingers
end: Which was my Plot and In-
tention, because those which un-
derstand the Mathematicks can
conceive them easily; others for
the most part will content them-
selves

By way of Advertisement.

selves onely with the Knowledge of them, without seeking the Reason.

Secondly, To give a greater grace to the practice of these Things, they ought to be concealed as much as they may, in the subtilty of the way ; for that which doth ravish the Spirits is, *An Admirable Effect, whose Cause is Unknown* ; which if it were discovered, half the pleasure is lost : therefore all the fineness consists in the dexterity of the Act, concealing the means, and changing often the Stream.

Thirdly, Great care ought to be had that one deceive not himself, that would declare by way of Art to deceive another : This will
make

Byway of Advertisement.

make the matter contemptible to ignorant Persons, which will rather cast the Fault upon the Science, than upon him that shews it : When the Cause is not in the Mathematical Principles, but in him that fails in the acting of it.

Fourthly, In certain Arithmetical Propositions they have only their Answers, as I found them in sundry Authors, which any one, being studious of Mathematical Learning, may find their Original, and also the way of their Operation.

Fifthly, Because the Number of these *PROBLEMS*, and their Dependances, are many and intermixed, I thought it convenient to gather them into a Table :
that

By way of Advertisement.

that so each one according to his
Fancy might make best choice of
that which might best please his
Palate, the matter being not of
one Nature, nor of like Subtilty :
But whosoever will have patience
to read on, shall find the End bet-
ter than the Beginning.

A



A T A B L E

OF THE

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Contracted according to the
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Specified in the Title-Page.

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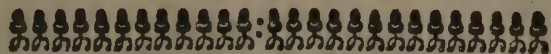
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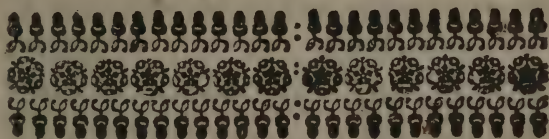
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Mathema-



Mathematical RECREATION.

PROBLEM I.

To find a Number thought upon.

BId him that he Quadruple the Number thought upon, that is, multiply it by 4, and unto it bid him to add 6, 8, 10, or any Number at pleasure : and let him take the half of the sum, then ask how much it comes to ? for then if you take away half the number from it which you willed him at first to add to it, there shall remain the double of the number thought upon.

B

Example.

Example.

The Number thought upon	5
The Quadruple of it	20
Put 8 unto it, makes	28
The half of it is	14
Take away half the number added, from it, viz. 4, the rest is	10
The double of the number thought upon, viz.	10

Another way to find what number was thought upon.

Bid him which thinketh double his Number, and unto that double add 4, and bid him multiply that same product by 5, and unto that product bid him add 12, and multiply that last number by 10 (which is done easily by setting a Cypher at the end of the number) then ask him the last number or product, and from it secretly subtract 320; the remainder in the hundreth place is the number thought upon.

Example.

The number thought upon	7	For which 700 account onely but the number of the hundreds, viz. 7. so have you the Number thought upon
His double	14	
To it add 4, makes	18	
Which multiplied by 5 makes	90	
To which add 12, makes	102	
This multiplied by 10 which is onely by ad- ding a Cypher to it, makes	1020	
From this subtract	320	
Rest	700	

To

To find Numbers conceived upon, otherwise than the former.

BId the party which thinks the number, that he tripple his thought, and cause him to take the half of it: (if it be odd, take the least half, and put one unto it) then will him to tripple the half, and take half of it, as before: Lastly, ask him how many Nines there is in the last half, and for every Nine, account four in your memory, for that shall shew the number thought upon, if both the tripples were even: but if it be odd at the first tripple, and even at the second, for the one added unto the least half keep one in memory: if the first tripple be even, and the second odd, for the one added unto the least half keep two in memory: lastly, if at both times in tripping, the numbers be odd, for the two added unto the least halves, keep three in memory: These cautions observed, and added unto as many fours as the party says there is Nines contained in the last half, shall never fail you to declare or discern truly what number was thought upon.

Example.

The Number thought upon	4 or 7
The tripple	12 or 21
The half thereof 6 or 10, one put to it makes	11
The tripple of the half	18 or 33
The half 9 or 16, one put to it makes	17
The number of Nines in the last half	1 or 1
B 2	The

The first 1 representeth 4, the number thought upon, and the last 1 with the caution makes 7, the other number thought upon.

Note.

Order your Method so that you be not discovered, which to help, you may with dexterity and industry make *Additions*, *Substractions*, *Multiplications*, *Divisions*, &c. and instead of asking how many Nines there is, you may ask how many Eights, Tens, &c. there is, or subtract Eight, Ten, &c. from the Number which remains, for to find out the Number thought upon.

Now touching the *Demonstrations* of the former Directions, and others which follow, they depend upon the 2, 7, 8, and 9 *Books* of the Elements of *Euclide*: Upon which second *Book* and fourth *Proposition*, this may be extracted, for those which are more learned, for the finding of any Number that any one thinketh on.

Bid the party that thinks, that he break the Number thought upon into any two parts, and unto the Squares of the parts let him add the double Product of the parts; then ask what it amounteth unto? So the *Root Quadrat* shall be the Number thought upon.

Exam-

Example.

The Number thought upon		5
The parts suppose		3 and 2
The Square of 3 makes 9	} the sum of these three numbers 25, the square Root of which is 5, the number thought upon	
The Square of 2 makes 4		
The product of the parts, viz. 3 by 2 makes 6, which 6 doubled makes 12		

Or more compendiously it may be delivered thus:

Break the Number into two parts, and to the Product of the parts add the Square of half the difference of the parts, then the Root Quadrat of the Aggregate is half the Number conceived.

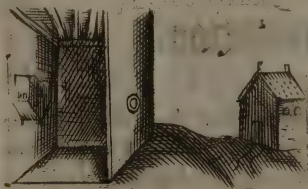
Examination.

THe Problems which concern Arithmetick, we examine not : for these are easie to any one which hath read the Grounds and Principles of Arithmetick ; but we especially touch upon that which tends to the Speculations of Physick, Geometry, and Opticks, and such others which are of more difficulty, and more principally to be examined and considered.

PROBLEM II.

How to represent to those which are in a Chamber, that which is without, or all that which passeth by.

THis is one of the finest Experiments in the *Optiques*, and it is done thus : Chuse a Chamber or Place which is towards the Street, frequented with People, or which is against some fair flourishing Object, that so it may be more delightful and pleasant to the Beholders, then make the Room dark by shutting out the light, except a small hole of sixpence broad ; this done, all the Images and Species of the Objects which are without, will be seen within, and you shall have pleasure to see it, not only upon the Wall,



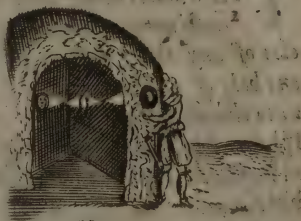
but especially upon a sheet of white Paper, or some White Cloth hung near the hole : and if unto the hole you place a round Glass, that is, a Glass which is thicker in the middle than at the edge : such as is the common Burning Glasses, or such which old People use : for then the Images which before did seem dead, and of a darkish colour, will appear and be

Mathematical Recreation. 7

be seen upon the Paper, or white Cloth, according to their natural colours, yea more lively than their natural, and the appearances will be so much the more beautiful and perfect, by how much the hole is lesser, the day clear, and the Sun shining.

It is pleasant to see the beautiful and goodly Representation of the Heavens, intermixed with Clouds in the Horizon, upon a Woody Situation, the motion of Birds in the Air, of Men and other Creatures upon the Ground, with the trembling of Plants, Tops of Trees, and such like: For every thing will be seen within, even to the life, but inversed: Notwithstanding, this beautiful Paint will so naturally represent it self in such a lively Perspective, that hardly the most accurate Painter can represent the like.

Now the reason why the Images and Objects without are inversed, is because the Species do intersect one another in the hole, so that the Species of the feet ascend, and those of the head descend.



But here note, that they may be represented right two manner of ways: First, with a Concave Glas: secondly, by help of another Convex Glas, disposed or placed between the Paper and the other Glas, as may be seen here by the Figure.

8 Mathematical Recreation.

Now I will add here only by passing by, for such which affect Painting and Portraiture, that this Experiment may excellently help them in the lively painting of things perspective-wise, as *Topographical Cards*, &c. and for Philosophers, it is a fine Secret to explain the Organ of the sight, for the hollow of the Eye is taken as the close Chamber, the Ball of the Apple of the Eye, for the hole of the Chamber, the Crystalline humour at the small of the Glass, and the bottom of the Eye, for the Wall or Leaf of Paper.

Examination.

THe Species being pressed together, or contracted, doth not perform it upon a Wall, for the species of any thing doth represent it self not onely in one hole of a Window, but in infinite holes, even unto the whole Sphere, or at least unto a Hemisphere (intellectual in a free Medium) if the Beams or Reflections be not interposed, and by how much the hole is made less, to give passage to the Species, by so much the more lively are the Images formed.

In Convex or Concave Glasses, the Images will be disproportionable to the Eye, by how much they are more Concave, or Convex, and by how much the parts of the Image comes near to the Axis, for those that are near, are better proportioned than those which are farther off.

But

Mathematical Recreation. 9

But to have them more lively and true, according to the Imaginary Conical Section, let the hole be no greater than a pins head made upon a piece of thin Brass, or such like, which hole represents the top of the Cone, and the Base thereof the Term of the Species: This practice is best when the Sun shines upon the hole, for then the Objects which are opposite to that Plain will make two like Cones, and will lively represent the things without in a perfect inversed Perspective, which drawn by the Pencil of some Artificial Painter, turn the Paper upside-down, and it will be direct, and to the life.

But the apparances may be direct, if you place another hole opposite unto the former, so that the Spectator be under it; or let the Species reflect upon a Concave Glass, and let that Glass reflect upon a Paper, or some white thing.

PROBLEM III.

To tell how much weighs the blow of ones fist, of a Mallet, Hatchet, or such like, or resting without giving the blow.

Scaliger in his 331 exercise against Cardan, relates that the Mathematicians of Maximilian the Emperour, did propose upon a day this Question, and promised to give the resolution; notwithstanding Scaliger delivered it not, and conceive it to be thus: Take a Balance, and let the
Fist,

Fist, the Mallet, or Hatchet rest upon the Scale, or upon the Beam of the Ballance, and put into the other Scale as much weight as may counterpoise it, then charging or laying more weight into the Scale, and striking upon the other end, you may see how much one blow is heavier than another, and so consequently how much it may weigh: for as *Aristotle* saith, *The motion that is made in striking adds great weight unto it, and so much the more, by how much it is quicker*: there-



fore in effect, if there were placed a thousand Mallets, or a Thousand Pound weight upon a stone, nay, though it were exceedingly pressed down by way of a Vice, by Levers, or

other Mechanick Engine, it would be nothing to the rigor and violence of a blow.

Is it not evident that the edge of a Knife laid upon Butter, and a Hatchet upon a Leaf of Paper, without striking makes no impression, or at least enters not? But striking upon the Wood a little, you may presently see what effect it hath; which is from the Quickness of the Motion, which breaks and enters without resistance, if it be extream quick; as experience shews us in the blows of Arrows, of Cannons, Thunder-bolts, and such-like.

Examination.

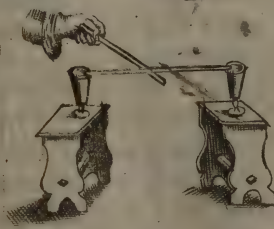
THis Problem was extracted from Scaliger, who had it from Aristotle, but somewhat refractory compiled, and the strength of the Effect he says depends onely in the violence of the Motion; then would it follow that a little light Hammer upon a piece of Wood being quickly caused to smite, would give a greater blow, and do more hurt than a great Sledge striking soft; this is absurd, and contrary to Experience. Therefore it consists not totally in the Motion: for if two several Hammers, the one being twenty times heavier than the other, should move with like Quickness, the Effect would be much different: there is then something else to be considered besides the Motion, which Scaliger understood not: for if one should have asked him what is the reason that a Stone falling from a Window to a place near at hand, is not so forceable as if it fell farther down; and when a Bullet flying out of a Piece, and striking the Mark near at hand, will not make such an Effect as striking the Mark farther off. But we suppose that Scaliger and Cardanus who handles this subject, would not be less troubled to resolve this, than they have been in that.

PRO-

PROBLEM IV.

How to break a Staff which is laid upon two Glasses full of Water, without breaking the Glasses, or spilling the Water; or upon two Reeds or Straws, without breaking of them.

First, place the Glasses which are full of Water upon two Joynt Stools, or such like, the one as high as the other from the ground, and distant one from another by two or three foot, then place the ends of the Staff upon the edges of the two Glasses, so that they be sharp: this done, with all the force you can, with another Staff



the middle, and it will break without breaking the Glasses, or spilling the Water.

In like manner may you do upon two Reeds, held with your hands in the

Air without breaking them: Thence Kitchen-Boys often break Bones of Mutton upon their hand, or with a Napkin, without any hurt, in onely striking upon the middle of the Bone with a Knife.

Now

Now in this Act, the two ends of the Staff in breaking slides away from the Glasses, upon which they were placed; hence it cometh that the Glasses are no wise endangered, no more than the Knee upon which a Staff is broken, forasmuch as in breaking it presseth not: as *Aristotle* in his *Mechanick Questions* observeth.

Examination.

IT were necessary here to note, that this thing may be experimented, first, without Glasses, in placing a small slender Staff upon two props, and then making trial upon it; by which you may see how the Staff will either break, bow, or depart from its props, and that either directly, or obliquely: But why by this violence, that one Staff striking another, (which is supported by two Glasses) will be broken without offending the Glasses, is as great a difficulty to be resolved as the former.

PRO-

PROBLEM V.

How to make a fair Geographical Card in a Garden-Plot, fit for a Prince, or Great Personage.

IT is usual amongst Great Men to have fair *Geographical Maps*, large *Cards*, and great *Globes*, that by them they may as at once have a view of any place of the World, and so furnish themselves with a general knowledge not onely of their own Kingdoms Form, Situation, Longitude, Latitude, &c. but of all other places in the whole Universe, with their Magnitudes, Positions, Climates and Distances.

Now I esteem that it is not unworthy for the Meditations of a Prince, seeing it carries with it many Profitable and Pleasant Contentments: if such a Card or Map by the Advice and Direction of an able Mathematician were Geographically described in a Garden-plot form, or in some other convenient place, and instead of which general description might particularly and artificially be prefigured his whole Kingdoms and Dominions; the Mountains and Hills being raised like small Hillocks with Turfs of Earth, the Valleys somewhat concave, which will be more agreeable and pleasing to the Eye, than the Description in plain Maps and Cards, within which may be presented the Towns, Villages, Castles, or
other

Mathematical Recreation. 15

other remarkable Edifices, in small green Mossie Banks, or Spring-work proportional to the Platform, the Forrests and Woods represented according to their form and capacity, with Herbs and Stoubs, the great Rivers, Lakes, and Ponds, to dilate themselves according to their course from some artificial Fountain made in the Garden to pass through Channels; then may there be composed Walks of Pleasure, Ascents, Places of Repose, adorned with all variety of delightful Herbs and Flowers, both to please the Eye and other Senses. A Garden thus accommodated, shall far exceed that of my Lord of *Verulams*, specified in his Essays; that being only for delight and pleasure, this may have all the properties of that, and be also of singular use; by which a Prince may in little time personally visit his whole Kingdom, and in short time know it distinctly: and so in like manner may any particular man Geographically prefigure his own Possession or Heritage.

PROBLEM VI.

How three Staves, Knives, or like Bodies, may be conceived to hang in the Air, without being supported by any thing but by themselves.

TAKE the first Staff A B, raise up in the Air the end B, and upon him cross-wise place the Staff C B, then lastly in Triangle wise place the third Staff E F, in such manner that it may
be

be under A B, and yet upon C D. I say that these Staves so disposed cannot fall, and the space C B E is made the stronger, by how much the more it is pressed down, if the Staves break not,



or sever themselves from the triangular form : so that always the Center of gravity be in the Center of the Triangle : for A B is supported by E F, and E F is held up

by C D, and C D is kept up from falling by A B, therefore one of these Staves cannot fall, and so by consequence none.

PROBLEM VII.

How to dispose as many men, or other things, in such sort, that rejecting or casting away the 6, 9, 10 part, unto a certain number, there shall remain those which you would have.

Ordinarily the proposition is delivered in this wise : 15 Christians and 15 Turks being at Sea in one Ship, an extream tempest being risen, the Pilot of the Ship saith, it is necessary to cast over-board half of the number of Persons to disburthen the Ship, and to save the rest : now it was agreed to be done by lot, and therefore they

consent

consent to put themselves in rank, counting by nine and nine, the ninth Person should always be cast into the Sea, until there were half thrown over-board : Now the Pilot being a Christian endeavoured to save the Christians ; how ought he therefore to dispose the Christians, that the Lot might fall always upon the Turks, and that none of the Christians be in the ninth place ?

The resolution is ordinarily comprehended in this Verse :

Populeam virgam mater regina ferebat.

For having respect unto the Vowels, making *a* one, *e* two, *i* three, *o* four, and *u* five : *o* the first Vowel in the first Word sheweth that there must be placed four Christians ; the next Vowel *u*, signifieth that next unto the four Christians must be placed five Turks ; and so to place both Christians and Turks according to the quantity and value of the Vowels in the Words of the Verse, until they be all placed : for then counting from the first Christian that was placed, unto the ninth, the lot will fall upon a Turk, and so proceed. And here may be further noted, That this Problem is not to be limited, seeing it extends to any number and order whatsoever, and may many ways be useful for Captains, Magistrates, or others, which have divers persons to punish, and would chastise chiefly the unruliest of them, in taking the 10, 20, or 100 person, &c. as we read was

commonly practised amongst the ancient *Romans*: therefore to apply a general Rule in counting the third, 4, 9, 10, &c. amongst 30, 40, 50 persons, and more or less; this is to be observed, take as many Unites as there are Persons, and dispose them in order privately: As for example, Let 24 men be proposed to have committed some outrage, 6 of them especially are found accessary; and let it be agreed that counting by 8 and 8, the eighth man should be always punished. Take therefore first 24 units, or upon a piece of Paper write down 24 cyphers, and account from the beginning to the eighth, which eighth mark, and so continue counting, always marking the eighth, until you have markt 6, by which you may easily perceive how to place those six men that are to be punished, and so of others.

It is supposed that *Josephus* the Author of the *Jewish History* escaped the danger of death by help of this Problem: For a worthy Author of belief reports in his eighth Chapter of the third Book of the destruction of *Jerusalem*, that the Town of *Jotapata* being taken by main force by *Vespasian*, *Josephus* being Governour of that Town, accompanied with a Troop of forty Souldiers, hid themselves in a Cave, in which they resolved rather to famish, than to fall into the hands of *Vespasian*: and with a bloody resolution in that great distress would have butchered one another for sustenance, had not *Josephus* perswaded them to die by lot and order, upon which it should fall: Now seeing that *Josephus* did save himself by this Art, it is thought that his

his Industry was exercised by the help of this Problem, so that of the 40 persons which he had, the third was always killed. Now by putting himself in the 16 or 31 place, he was saved, and one with him, which he might kill, or easily perswade to yield unto the *Romans*.

PROBLEM VIII.

Three Things and three Persons proposed, to find which of them hath either of these three Things.

L Et the three things be a *Ring*, a piece of *Gold*, and a piece of *Silver*, or any other such like, and let them be known privately to your self by these three Vowels, *a, e, i*, or let there be three persons that have different names, as *Ambrose*, *Edmond*, and *John*, which privately you may note or account to your self once known by the aforesaid Vowels, which signifie for the first Vowel 1, for the second Vowel 2, for the third Vowel 3.

Now if the said three persons should by the mutual consent of each other privately change their names, it is most facil by the course and excellency of Numbers, distinctly to declare each ones name so interchanged: Or if three persons in private, the one should take a *Ring*, the other a piece of *Gold*, and the third should take a piece of *Silver*; it is easie to find which hath the *Gold*, the *Silver*, or the *Ring*, and it is thus done.

C 2 Take

Take 30 or 40 Counters (of which there is but 24 necessary) that so you may conceal the way the better, and lay them down before the parties, and as they sit or stand give to the first 1 Counter, which signifieth *a*, the first Vowel; to the second 2 Counters, which represents *e*, the second Vowel; and to the third 3 Counters, which stand for *i* the third Vowel: then leaving the other Counters upon the Table, retire apart, and bid him which hath the Ring take as many Counters as you gave him, and he that hath the Gold, for every one that you gave him, let him take 2, and he that hath the Silver for every one that you gave him, let him take 4: This being done, consider to whom you gave one Counter, to whom two, and to whom three; and mark what number of Counters you had at the first; for there are necessarily but 24, as was said before, the surplus you may privately reject. And then there will be left either 1, 2, 3, 5, 6, or 7, and no other number can remain; which if there be, then they have failed in taking according to the directions delivered: but if either of these numbers do remain, the resolution will be discovered by one of these six words following, which ought to be had in memory, *viz.*

Salve, certa, anima, semita, vita, quies.

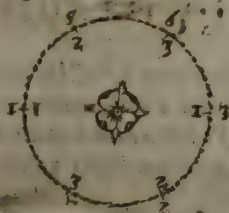
1. 2. 3. 5. 6. 7.

As suppose 5 did remain, the word belonging unto it is *semita*, the Vowels in the first two Syllables

Mathematical Recreation. 21

ables are *e* and *i*, which sheweth according to the former Directions, that to whom you gave 2 Counters, he hath the Ring, (seeing it is the second Vowel represented by two, as before) and to whom you gave the 3 Counters, he hath the Gold: for that *i* represents the third Vowel, or 3 in the former Direction, and to whom you gave one Counter, he hath the Silver; and so of the rest. The variety of changes in which exercise, is laid open in the Table following.

Rest.	Men.	Mid.	Rest.	Men.	Mid.
1	1	a	1	1	1
1	2	e	5	2	2
1	3	i	1	3	3
1	1	e	1	1	1
2	2	a	6	2	2
1	3	i	1	3	1
1	1	a	1	1	1
3	2	i	7	2	2
3	3	e	3	3	3



This feat may be also done without the former words, by help of the Circle A. for having divided the Circle into six parts, write 1 within and one without, two within and five without, &c. the first 1, 2, 3, which are within with the Numbers over them, belongs to the upper semicircle; the other Numbers both within and without, to the under semicircle;

C 3

now

now if in the action there remaineth such a number which may be found in the upper semicircle without, then that which is opposite within shews the first, the next is the second, &c. as if 5 remain, it shews to whom he gave 2, he hath the Ring; to whom you gave 3, he hath the Gold, &c. But if the remainder be in the under semicircle, that which is opposite to it is the first, the next backwards towards the right hand is the second; as if 3 remains, to whom you gave 1 he hath the Ring, he that had 3 he had the Gold, &c.

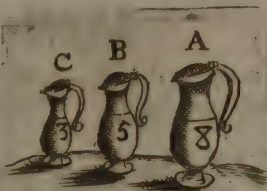
PROBLEM IX.

How to part a Vessel which is full of Wine, containing eight Pints, into two equal parts, by two other Vessels which contain as much as the greater Vessel; as the one being 5 Pints, and the other 3 Pints.

L Et the three Vessels be represented by A B C, A being full, the other two being empty; first, pour out A into B until it be full, so there will be in B 5 pints, and in A but 3 pints: then pour out of B into C until it be full: so in C shall be 3 pints, in B 2 pints, and in A 3 pints, then pour the Wine which is in C into A, so in A will be 6 pints, in B 2 pints, and in C nothing: then pour out the Wine which is in B into the pot C, so in C there is now 2 pints, in B nothing, and in A 6 pints. Lastly, pour out of A into B untill it be full, so there will be now in A only 1 pint

pint, in B 5 pints, and in C 2 pints. But it is now evident, that if from B you pour in unto the pot C until it be full,

there will remain in B 4 pints, and if that which is in C, viz. 3 pints be poured into the vessel A, which before had 1 pint, there shall be in the vessel A but half of

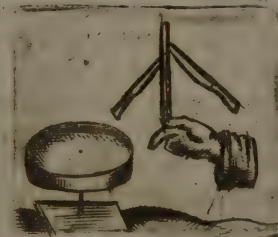


its liquor that was in it at the first, viz. 4 pints, as was required. Otherwise pour out of A into C until it be full, which pour into B, then pour out of A into C again until it be full, so there is now in A only 2 pints, in B 3, and in C 3, then pour from C into B until it be full, so in C there is now but 1 pint, 5 in B, and 2 in A : pour all that is in B into A, then pour the Wine which is in C into B, so there is in C nothing, in B only 1 pint, and in A 7 pints: Lastly, out of A fill the pot C, so there will remain in A 4 pints, or be but half full: then if the liquor in C be poured into B, it will be the other half. In like manner might be taken the half of a Vessel which contains 12 pints, by having but the measures 5 and 7, or 5 and 8. Now such others might be proposed, but we omit many, in one and the same nature.

PROBLEM X.

To make a Stick stand upon the tip of ones Finger, without falling.

Fasten the edges of two Knives, or such like, of equal poise, at the end of the Stick, leaning out somewhat from the Stick, so that they may counterpoise one another; the Stick being sharp at the end, and held upon the top of the Finger, will there rest without supporting: if it fall, it must fall together, and that perpen-



dicular, or plumb-wise, or it must fall side-wise, or before one another; in the first manner it cannot, for the Centre of Gravity is supported by the top of the Finger: and seeing

that each part by the Knives is counterpoised, it cannot fall side-wise, therefore it can fall no wise.

In like manner may great Pieces of Timber, as Joists, &c. be supported, if unto one of the Ends be applied convenient proportional Counterpoises; yea a Lance or Pike may stand perpendicular in the Air, upon the top of ones Finger: or placed in the midst of a Court, by help of his Centre of Gravity.

Exam.

Examination.

THis Proposition seems doubtful; for to imagine absolutely, that a Pike, or such-like, armed with two Knives, or other things, shall stand upright in the air, and so remain, without any other support, seeing that all the parts have an infinite difference of propensity to fall; and it is without question that a Staff cannot be so accommodated upon his Centre of Gravity, but that it may incline to some one part, without some remedy to be applied, and such as is here specified in the Problem will not warrant the thing, nor keep it from falling; and if more Knives should be placed about it, it should cause it to fall more swiftly, forasmuch as the superiour part (by reason of the Centrical Motion) is made more ponderous, and therefore less in rest.

To place therefore this Prop really, let the two Knives, or that which is for counterpoise, be longer always than the Staff, and so it will hang together as one body: and it will appear admirable if you place the Centre of Gravity near the side of the top of the finger or point; for it will then hang Horizontal, and seem to hang onely by a touch; yet more strange, if you turn the point or top of the finger upside-down.

PRO-

PROBLEM XI.

How a Milstone or other Ponderosity may be supported by a small Needle, without breaking or any wise bowing the same.

Let a Needle be set perpendicular to the Horizon, and the Centre of Gravity of the Stone be placed on the top of the Needle : it is evident that the Stone cannot fall, forasmuch as it hangs in *equilibra*, or is counterpoysed in all parts alike ; and moreover it cannot bow the Needle more on the one side, then on the other ; the Needle will not therefore be either broken or bowed ; if otherwise, then the parts of the Needle must penetrate and sink one with another ; the which is absurd and impossible to Nature : therefore it shall be supported. The Experi-



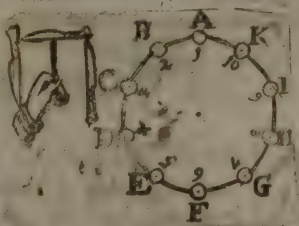
ments which are made upon Trencher-Plates, or such-like lesser thing, doth make it most credible in greater Bodies. But here especially is to be noted, that the Needle ought to be uniform in matter and figure, and that it be erected perpendicular to the Horizon ; and lastly, that the Centre of Gravity be exactly found.

PRO-

PROBLEM XII.

To make three Knives hang and move upon the point of a Needle.

F If the three Knives in form of a Balance, and holding a Needle in your hand, place the back of that Knife which lies cross-wise to the other two, upon the point of the Needle, as the figure here sheweth you; for then in blowing softly upon them, they will easily turn and move upon the point of the Needle without falling.



PROBLEM XIII.

To find the weight of Smoak, which is exhaled of any combustible Body whatsoever.

L Et it be supposed that a great heap of Fagots, or a load of Straw weighing 500 pound should be fired, it is evident that this gross substance will be all inverted into smoak and
ashes;

ashes : now it seems that the smoak weighs nothing, seeing it is of a thin substance now dilated in the Air, notwithstanding if it were gathered and reduced into the thickest that it was at first, it would be sensibly weighty : weigh therefore the ashes which admit 50 pound : Now seeing that the rest of the matter is not lost, but is exhaled into smoak, it must necessarily be, that the rest of the weight (to wit, 450 pound) must be the weight of the smoak required.

Examination.

NOW although it be thus delivered, yet here may be noted, that a Ponderosity in his own Medium is not weighty : for things are said to be weighty, when they are out of their place or medium, and the difference of such Gravity, is according to the Motion : the smoak therefore certainly is light, being in its true medium (the Air) if it should change his Medium, then would we change our discourse.

PROBLEM XIV.

Many things being disposed circular, (or otherwise) to find which of them any one thinks upon.

SUPPOSE that having ranked 10 things, as A B C D E F G H I K, Circular, as (the Figure sheweth) and that one had touched or thought upon

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upon G, which is the 7: ask the party at what letter he would begin to account (for account he must, otherwise it cannot be done) which suppose at E, which is the 5 place, then add secretly to this 5, 10, (which is the number of the Circle) and it makes 15, bid him account 15 backward from E, beginning his account with that number he thought upon, so at E he shall account to himself 7, at D account 8, at C account 9, &c. So the account of 15 will exactly fall upon G, the thing or number thought upon: and so of others: but to conceal it the more, you may will the party from E to account 25, 35, &c. and it will be the same.



There are some that use this play at Cards, turned upside-down, as the ten simple Cards, with the King and Queen, the King standing for 12, and the Queen for 11: and so knowing the situation of the Cards, and thinking a certain hour of the day, cause the party to account from what Card he pleaseth; with this Proviso, that when you see where he intends to account, set 12 to that number, so in counting as before, the end of the account shall fall upon the Card which shall denote or shew the hour thought upon, which being turned up, will give grace to the action, and wonder to those that are ignorant in the cause.

PRO-

PROBLEM XV.

How to make a Door or Gate, which shall open on both sides.

ALl the skill and subtilty of this, rests in the artificial disposure of four Plates of Iron, two at the higher end, and two at the lower end of the Gate: so that one side may move upon the Hooks or Hinges of the Posts, and by the other end may be made fast to the Gate; and so moving upon these Hinges, the Gate will open upon one side with the aforesaid Plates or Hooks of Iron: and by help of the other two Plates will open upon the other side.

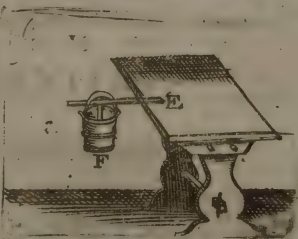
PROBLEM XVI.

To shew how a Ponderosity, or heavy thing, may be supported upon the end of a Staff (or such-like) upon a Table, and nothing holding or touching it.

TAKE a Pail which hath a handle, and fill it full of Water, (or at pleasure) then take a Staff or Stick which may not rowl upon the Table, as EC , and place the handle of the Pail upon the Staff; then place another Staff or Stick under the Staff CE , which may reach from the bottom

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bottom of the Pail unto the former Staff C E, perpendicular wise, which suppose F G: then shall the Pail of Water hang without falling; for if it fall, it must fall perpendicularly, or plumb-wise; and that cannot be, seeing the Staff C E supports it, it being parallel to the Horizon, and sustained by the Table: and it is a thing admirable, that if the Staff C E were alone from the Table, and that end of the Staff which is upon the Table were greater and heavier than the other, it would be constrained to hang in that nature.



Examination.

NOW without some Experience of this Problem, a man would acknowledge either a possibility or impossibility; therefore it is that very Touchstone of Knowledge in any thing, to discourse first if a thing be possible in Nature, and then if it can be brought to Experience, and under Sense, without seeing it done. At the first, this Proposition seems to be absurd, and impossible. Notwithstanding, being supported with two Sticks, as the figure declareth, it is made facile: for the Horizontal Line to the edge of the

the Table, in the Centre of Motion; and passeth by the Centre of Gravity, which necessarily supporteth it.

PROBLEM XVII.

Of a deceitful Bowle to play withal.

Make a hole in one side of the Bowl, and cast molten Lead therein, and then make up the hole close, that the knavery or deceit be not perceived: you will have pleasure to see that notwithstanding the Bowl is cast directly to the play, how it will turn away side-wise: for that on that part of the Bowl which is heavier upon the one side than the other, it never will go truly right, if artificially it be not corrected; which will hazard the Game to those which know it not: but if it be known that the leady side in rolling be always under or above, it may go indifferently right; if otherwise, the weight will carry it always side-wise.

PROBLEM XVIII.

To part an Apple into 2, 4, 8, or like parts, without breaking the Rind.

PAss a Needle and Thread under the Rind of the Apple, and then round it with divers turnings, until you come to the place where you began:

Mathematical Recreation. 33

began; then draw out the Thread gently, and part the Apple into as many parts as you think convenient: and so the parts may be taken out between the parting of the Rind, and the Rind remaining always whole.

PROBLEM XIX.

To find a number thought upon, without asking of any question, certain operations being done.

BId him add to the number thought (as admit 15) half of it, if it may be, if not, the greatest half, that exceeds the other but by an unite, which is 8; and it makes 23. Secondly, unto this 23 add the half of it, if it may be, if not, the greatest half, viz. 12, makes 35; in the mean time, note that if the number thought upon cannot be halved at the first time, as here it cannot, then for it keep three in the memory; if at the second time it will not be equally halved, reserve two in memory, but if at both times it could not be equally halved, then may you together reserve five in memory: this done, cause him from the last sum, viz. 35, to subtract the double of the number thought, viz. 30, rest five, will him to take the half of that, if he can, if not, reject 1, and then take the half of the rest, which keep in your memory: then will him to take the half again, if he can, if not, take one from it, which reserve in your memory;

D

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memory, and so perpetually halving until 1 remain : for then mark how many halfs there were taken, for the first half account 2, for the second 4, for the third 8, &c. and add unto those numbers the ones which you reserved in memory : So there being 5 remaining in this Proposition, there were 2 halvings: for which last I account 4, but because it could not exactly be halved without rejecting of 1, I add the 1 therefore to this 4, makes 5, which half or sum always multiplied by 4, makes 20. from which subtract the first 3 and 2, because the half could not be formerly added, leaves 15, the number thought upon.

Another Example.

The number thought	_____	12
The half of it	_____	6
The sum	_____	18
The half of it	_____	9
The sum of it	_____	27
The double of the number	_____	24
Which taken away, rests	_____	3
The half of it	_____	1
For which account	_____	2
And 1 put to it because the 3 could not be halved, makes	_____	3
This multiplied by 4, makes	_____	12
Which was the number thought upon.		

Another

Another Example.

The number thought-_____ 79
 The greatest half _____ 40 3
 The sum-_____ 119
 The greatest half of which is _____ 60 2
 The sum of it is _____ 179
 The double of 79 is _____ 158
 Which taken from it rests-- _____ 21
 The lesser half 10, which halve :-- _____
 The half of this is 5, which makes _____
 The half of this is 2, which is _____ 10
 The half of this is 1, with 10 and 11 is _____ 21
 This 21 which is the double of the last half, }
 with the remainder, being multiplied by } 79
 4, makes 84, from which take the afore- }
 said 3 and 2, rests-- _____ }
 Which was the number thought upon.

PROBLEM XX.

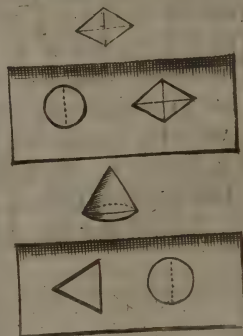
*How to make an uniform and inflexible Body to pass
 through two small holes of divers forms, as one
 being circular and the other square, Quadrangu-
 lar, and Triangular-wise, yet so that the holes
 shall be exactly filled.*

THis Problem is extracted from Geometri-
 cal Observations, and seems at the first
 somewhat obscure; yet that which may be ex-
 D 2 tracted

tracted in this nature, will appear more difficult and admirable. Now in all Geometrical Practices, the lesser or easier Problems do always make way to facilitate the greater: and the aforesaid Problem is thus resolved. Take a Cone or round Pyramide, and make a Circular hole in some board, or other hard material, which may be equal to the Bases of the Cone, and also a Triangular hole, one of whose sides may be equal to the Diameter of the Circle, and the other two sides equal to the length of the Cone: Now it is most evident, that this

Conical or Pyramidal Body, will fill up the Circular hole, and being placed side-wise, will fill up the Triangular hole. Moreover if you cause a body to be turned, which may be like to two Pyramids conjoyned, then if a Circular hole be

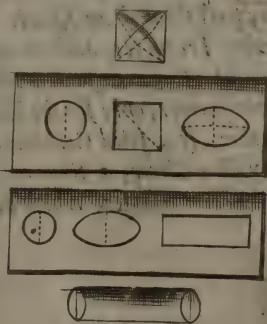
made, whose Diameter is equal to the Diameter of the Cones conjoyned, and a Quadrangular hole, whose sloping sides be equal to the length of each side of the Pyramide, and the breadth of the hole equal to the Diameter of the Circle, this conjoyned Pyramide shall exactly fill both the Circular hole, and also the Quadrangular hole.



PROBLEM XXI.

How with one uniform Body, or such-like, to fill three several holes: of which the one is round, the other a just square, and the third an oval form.

THIS Proposition seems more subtil than the former, yet it may be practised two ways: For the first, take a Cylindrical Body, as great or little as you please: Now it is evident that it will fill a Circular hole, which is made equal to the Basis of it, if it be placed down right, and will also fill a long Square, whose sides are equal unto the Diameter and length of the Cylinder, and according to *Pergeus, Archimedes, &c.* in their Cylindrical Demonstrations, a true Oval is made when a Cylinder is cut slope-wise, therefore if the Oval have breadth equal unto the Diameter of the Basis of the Cylinder, and any length whatsoever: the Cylinder being put into his own Oval hole,



The second way is thus: Make a circular hole in some board, and also a square hole, the side of which square may be equal to the Diameter of the Circle: and lastly, make a hole Oval-wise, whose breadth may be equal unto the Diagonal of the Square; then let a Cylindrical Body be made, whose Basis may be equal unto the Circle, and the length equal also to the same: Now being placed down-right, shall fall in the Circle, and flat-wise will fit the Square hole, and being placed sloping-wise will fill the Oval.

Examination.

YOU may note upon the last two Problems farther, that if a Cone be cut Ecliptick-wise, it may pass through an Isosceles Triangle, through many Scalene Triangles, and through an Ellipsis; and if there be a Cone cut scalen-wise, it will pass through all the former, only for the Ellipsis place a Circle: and further, if a solid Columbe be cut Ecliptick-wise, it may fill a Circle, a Square, divers Parallelograms, and divers Ellipses, which have different Diameters.

PRO-

PROBLEM XXII.

To find a number thought upon, after another manner than what is formerly delivered.

Bid him that he multiply the number thought upon, by what number he pleaseth, then bid him divide that product by any other number, and then multiply that Quotient by some other number; and that product again divide by some other, and so as often as he will: and here note, that he declare or tell you by what number he did multiply and divide. Now in the same time take a number at pleasure, and secretly multiply and divide as often as he did: then bid him divide the last number by that which he thought upon. In like manner do yours privately, then will the Quotient of your Divisor be the same with his, a thing which seems admirable to those which are ignorant of the cause. Now to have the number thought upon without seeming to know the last Quotient, bid him add the number thought upon to it, and ask him how much it makes: then subtract your Quotient from it, there will remain the number thought upon. For Example: Suppose that the number thought upon were 5, multiply it by 4, makes 20; this divided by 2, the Quotient makes 10, which multiplied by 6, makes 60, and divided

D 4

by

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by 4, makes 15, in the same time admit you think upon 4, which multiplied by 4, makes 16, this divided by 2, makes 8, which multiplied by 6 makes 48, and divided by 4 makes 12; then divide 15 by the number thought, which was 5, the Quotient is 3; divide also 12 by the number you took, viz. 4, the Quotient is also 3, as was declared; therefore if the Quotient 3 be added unto the number thought, viz. 5, it makes 8; which being known, the number thought upon is also known.

8.
 $\frac{15}{5} = 3$
 $\frac{12}{4} = 3$
 3 + 5 = 8

PROBLEM XXIII.

To find out many numbers that sundry persons, or one man, hath thought upon.

IF the multitude of numbers thought upon be odd, as three numbers, five numbers, seven, &c. As for example: Let 5 numbers thought upon be these, 2, 3, 4, 5, 6, bid him declare the sum of the first and second, which will be 5, the second and third, which makes 7, the third and fourth, which makes 9, the fourth and fifth, which makes 11, and so always adding the two next together, ask him how much the first and last makes together, which is 8, then take these sums and place them in order, and add all these together which were in the odd places: that is, the first, third and fifth, viz. 5, 9, 8, makes 22. In like manner add all these numbers together, which

which are in the even places, that is in the second and fourth places, viz. 7 and 11 makes 18, subtract this from the former 22, then there will remain the double of the first number thought upon, viz. 4, which known, the rest is easily known: seeing you know the sum of the first and second; but if the multitude of numbers be even as these six numbers, viz. 2, 3, 4, 5, 6, 7. cause the party to declare the sum of each two, by antecedent and consequent, and also the sum of the second and last, which will be 5, 7, 9, 11, 13, 10, then add the odd places together, except the first, that is, 9 and 13 makes 22; add also the even places together, that is 7, 11, 10, which makes 28; subtract the one from the other, there shall remain the double of the second number thought upon, which known, all the rest are known:

PROBLEM XXIV.

How is it that a man in one and the same time, may have his Head upward and his Feet upward, being in one and the same place?

THe Answer is very facil, for to be so, he must be supposed to be in the Centre of the Earth: for as the Heaven is above on every side, *Cælum undique sursum*, all that which looks to the Heavens, being distant from the Centre, is upward; and it is in this sense that *Maurolycus* in

in his Cosmography, and first Dialogue, reported of one that thought he was led by one of the Muses to Hell, where he saw *Lucifer* sitting in the middle of the World, and in the Centre of the Earth, as in a Throne, having his Head and Feet upward.

PROBLEM XXV.

Of a Ladder by which two men ascending at one time, the more they ascend the more they shall be asunder, notwithstanding one being as high as another.

THis is most evident, that if there were a Ladder half on this side of the Centre of the earth, and the other half on the other side: and that two at the Centre of the World at one instant being to ascend, the one towards us, and the other towards our Antipodes, they should in ascending go farther & farther, one from another; notwithstanding both of them are of like height.

P.R.O.

PROBLEM XXVI.

How it is that a man having but a Rod or Pole of Land, doth brag that he may in a right line pass from place to place above 3000 miles.

THe opening of this is easie, forasmuch as he that possesseth a Rod of Ground, possesseth not only the exterior surface of the earth, but is Master also of that which extends even to the Centre of the Earth, and in this wise all Heritages and Possessions are as so many Pyramides, whose summets or points meet in the Centre of the Earth, and the Basis of them are nothing else but each mans possession, field, or visible quantity; and therefore if there were made or imagined so to be made a descent to go to the bottom of the Heritage, which would reach to the Centre of the Earth, it would be above 3000 miles in a right line, as before.

PROBLEM XXVII.

How it is that a man standing upright, and looking which way he will, he looketh either true North or true South.

THis happeneth if the party be under either of the Poles; for if he be under the North-pole, then looking any way he looketh South, because

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cause all the Meridians concur in the Poles of the World ; and if he be under the South-Pole, he looks directly North by the same reason.

PROBLEM XXVIII.

To tell any one what number remains after certain operations being ended, without asking any question.

BId him to think upon a number, and will him to multiply it by what number you think convenient : and to the product bid him add what number you please, provided that secretly you consider, that it may be divided by that which multiplied, and then let him divide the sum by the number which he first multiplied by, and subtract from this Quotient the number thought upon : In the same time divide apart the number which was added by that which multiplied, so then your Quotient shall be equal to his Remainder ; wherefore without asking him any thing, you shall tell him what did remain, which will seem strange to him that knoweth not the cause. For Example : Suppose he thought 7, which multiplied by 5 makes 35, to which add 10, makes 45, which divided by 5, yields 9, from which if you take away 1, the number thought, (because the Multiplier divided by the Divisor gives the Quotient 1) the rest will be 2 ; which will be also proved, if 10, the number which was added, were divided by 5, viz. 2.

PRO-

PROBLEM XXIX.

Of the Play with two several things.

IT is a pleasure to see and consider how the Science of Numbers doth furnish us not onely with sports to recreate the Spirits, but also brings us to the knowledge of admirable things, as shall in some measure be shewn in this ensuing Progression. In the mean time, to produce always some of them: Suppose that a man hold divers things in his hand, as Gold and Silver, and in one hand he held the Gold, and in the other hand he held the Silver: to know subtilly, and by way of divination, or artificially, in which hand the Gold or Silver is; attribute to the Gold, or suppose it to have a certain price, and so likewise attribute to the Silver another price, conditionally that the one be odd, and the other even. As for example: Bid him that the Gold be valued at 4 Crowns, or Shillings, and the Silver at 3 Crowns or Shillings, or any other number, so that one be odd, and the other even, as before; then bid him tripple that which is in the right hand, and double that which is in the left hand, and bid him add these two products together, and ask him if it be even or odd; if it be even, then the Gold is in the right hand; if odd, the Gold is in the left hand.

PRO.

PROBLEM XXX.

Two numbers being proposed unto two several parties, to tell which of these numbers is taken by each of them.

AS for Example: Admit you had proposed unto two men; whose names were *Peter* and *John*, two numbers or pieces of money, the one even, and the other odd, as 10 and 9; and let the one of them take one of the numbers, and the other party take the other number, which they place privately to themselves: how artificially, according to the congruity and excellency of numbers, to find which of them did take 10, and which 9, without asking any question: and this seems most subtil, yet delivered howsoever differing little from the former, and is thus performed: Take privately to your self also two numbers, the one even and the other odd, as 4 and 3; then bid *Peter* that he double the number which he took, and do you privately double also your greatest number; then bid *John* to triple the number which he hath, and do you the like upon your last number: add your two Products together, and mark if it be even or odd, then bid the two parties put their numbers together, and bid them take the half of it, which if they cannot do, then immediately tell *Peter* he took 10, and *John* 9, because the aggregate of the double

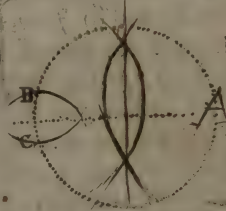
double of 4, and the tripple of 3, makes odd, and such would be the aggregate or sum of the double of *Peters* number and *Johns* number, if *Peter* had taken 10; if otherwise, then they might have taken half, and so *John* should have taken 10, and *Peter* 9 : As suppose *Peter* had taken 10, the double is 20, and the tripple of 9, the other number, is 27, which put together makes 47, odd : in like manner the double of your number conceived in mind, viz. 4 makes 8, and the tripple of the 3, the other number makes 9, which set together makes 17, odd. Now you cannot take the half of 17 nor 47, which argueth that *Peter* had the greater number, for otherwise the double of 9 is 18, and the tripple of 10 is 30, which set together makes 48, the half of it may be taken; therefore in such case *Peter* took the less number, and *John* the greater : And this being done cleanly, carries much grace with it.

PROBLEM XXXI.

How to describe a Circle that shall touch 3 Points, placed howsoever upon a plain, if they be not in a right line.

L Et the three points be A B C, put one foot of the Compass upon A, and describe an Arch of a Circle at pleasure; and placed at B cross that Arch in the two points E and F, and placed in C cross the Arch in G and H, then lay a Ruler

ler upon G H, and draw a Line, and place a Ruler upon E and F, cut the other Line in K, so K is the Centre of the Circumference of a Circle, which will pass by the said three points A B C, or it may be inverted, having a Circle drawn, to find the Centre of that Circle, make three points in the Circumference, and then use the same way; so shall you have the Centre: a thing most facil to every Practitioner in the Principles of Geometry.



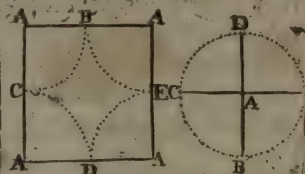
PROBLEM XXXII.

How to change a Circle into a Square Form.

MAKE a Circle upon Past-board, or other material, as the Circle A B C D E, of which A is the Centre; then cut it into four quarters, and dispose them so, that A, at the Centre of the Circle, may always be at the Angle of the Square; and so the four quarters of the Circle being placed so, it will

make

make a perfect Square, whose side A A is equal to the Diameter B D. Now here is to be noted that the Square is greater than the Circle by the vacuity in the middle, viz. M.

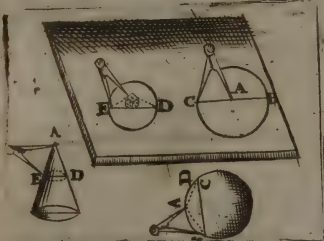


PROBLEM XXXIII.

With one and the same Compasses, and at one and the same extent or opening, how to describe many Circles Concentrical, that is, greater or lesser one than another.

IT is not without cause that many admire how this Proposition is to be resolved; yea, in the Judgment of some it is thought impossible, who consider not the Industry of an Ingenious Geometrician, who makes it possible, and that most facil, sundry ways: for in the first place, if you make a Circle upon a fine Plain, and upon the Centre of that Circle a small peg of Wood be placed, to be raised up and put down at pleasure, by help of a small hole made in the Centre, then with the same opening of the Compasses you may describe Circles Concentrical,

centrical, that is, one greater or lesser than another; for the higher the Centre is lifted up, the lesser the Circle will be. Secondly, the Compass being at that extent upon a *Gibbous* body, a Circle may be described, which will be less than the former, upon a Plain, and more artificially



upon a Globe, or round Bowle: and this again is most obvious upon a Round Pyramide, placing the Compasses upon the top of it, which will be far less than any of the former; and this

is demonstrated by the Twentieth Proposition of the first of *Euclids*, for the Diameter ED is less than the Lines AD , AE , taken together, and the Lines AD , AE , being equal to the Diameter BC , because of the same distance or extent of opening the Compasses, it follows that the Diameter ED , and all his Circles together, is much less than the Diameter and the Circle BC , which was to be performed.

PRO-

PROBLEM XXXIV.

Any numbers under 10, being thought upon, to find what numbers they were.

L Et the first number be doubled, and unto it add 5, and multiply that sum by 5, and unto it add 10, and unto this product add the next number thought upon; multiply this same again by 10, and add unto it the next number, and so proceed: Now if he declare the last sum, mark if he thought but upon one figure, for then subtract onely 35 from it, and the first figure in the place of tens is the number thought upon: if he thought upon two figures, then subtract also the said 35 from his last sum, and the two figures which remain are the number thought upon: if he thought upon three figures, then subtract 350, and then the first three figures are the numbers thought upon, &c. so if one thought upon these numbers, 5, 7, 9, 6, double the first makes 10, to which add 5, makes 15, this multiplied by 5 makes 75, to which add 10, makes 85, to this add the next number, viz. 7, makes 92, this multiplied by 10, makes 920, to which add the next number, viz. 9, makes 929, which multiplied by 10, makes 9290, to which add 6, makes 9296, from which subtract 3500, resteth 5796, the four numbers thought upon. Now because the two last figures are like the two num-

bers thought upon: to conceal this, bid him take the half of it, or put first 12, or any other number to it, and then it will not be so open.

PROBLEM XXXV.

Of the Play with the Ring.

AMongst a company of nine or ten persons, one of them having a Ring, or such-like, to find out in which Hand, upon which Finger and Joynt it is; this will cause great astonishment to ignorant Spirits, which will make them believe that he that doth it works by Magick, or Witchcraft: But in effect it is nothing else but a nimble Act of Arithmetick founded upon the precedent Problem: for first, it is supposed that the persons stand or sit in order, that one is first, the next second, &c. likewise there must be imagined, that of these two hands the one is first, and the other second; and also of the five fingers, the one is first, the next is second; and lastly, of the joynts, the one is as 1, the other is as 2, the other as 3, &c. from whence it appears that in performing this Play there is nothing else to be done than to think four numbers. For example: if the fourth person had the Ring in his left hand, and upon the fifth finger and third joynt, and I would divine and find it out, thus I would proceed, as in the XXXIV Problem, in causing him to double the first number, that is, the number of persons which

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which was 4, and it makes 8, to which add 5 makes 13, this multiplied by 5 makes 65, put 10 to it makes 75, unto this put 2 for the number belonging to the left hand, and so it makes 77, which multiplied by 10 makes 770, to this add the number of the fingers upon which the Ring is, *viz.* 5, makes 775, this multiplied by 10 makes 7750, to which add the number for the joynt upon which the Ring is, *viz.* the third joynt, makes 7753; to which cause him to add 14, or some other number, to conceal it the better, and it makes 7767: which being declared unto you, subtract 3514, and there will remain 4, 2, 5, 3, which figures in order declares the whole mystery of that which is to be known: 4 signifieth the fourth person, 2 the left hand, 5 the fifth finger, and 3 the third joynt of that finger.

PROBLEM XXXVI.

The Play of 34, or more Dice.

THat which is said of the two precedent Problems, may be applied to this of Dice, (and many other particular things) to find what number appeareth upon each Dice, being cast by some one: for the points that are upon any side of a Dice are always less than 10, and the Points of each side of a Dice may be taken for a number thought upon: therefore the Rule

E 3

will

will be as the former : As for example, one having thrown three Dice, and you would declare the numbers of each one, or how much they make together, bid him double the points of one of the Dice, to which bid him add 5, then multiply that by 5, and to it add 10, and to the sum bid him add the number of the second Dice, and multiply that by 10 : lastly, to this bid him add the number of the last Dice, and then let him declare the whole number : then if from it you subtract 350, there will remain the number of the three Dice thrown.

PROBLEM XXXVII.

How to make Water in a Glass seem to boyl and sparkle.

TAKE a Glass near full of Water or other liquor, and setting one hand upon the foot of it, to hold it fast : turn slightly one of the fingers of your other hand upon the brim or edge of the Glass ; having before privately wet your finger, and so passing softly on with your finger in pressing a little : for then first the Glass will begin to make a noise ; secondly, the parts of the Glass will sensibly appear to tremble, with notable rarefaction and condensation : thirdly, the Water will shake, seem to boyl ; fourthly, it will cast it self out of the Glass, and leap out by small drops, with great astonishment to the standers by ; if they

they be ignorant of the cause of it, which is only in the Rarefaction of the parts of the Glass, occasioned by the motion and pressure of the Finger.

Examination.

THe cause of this is not in the Rarefaction of the parts of the Glass, but it is rather in the quick local Motion of the Finger, for reason sheweth us that by how much a Body draweth nearer to a quality, the less it is subject or capable of another which is contrary unto it: Now Condensation and Rarefaction are contrary Qualities, and in this Problem there are three Bodies considered, the Glass, the Water, and the Air, now it is evident that the Glass being the most solid and impenetrable Body is less subject and capable of Rarefaction than the Water, the Water is less subject than the Air, and if there be any Rarefaction, it is rather considerable in the Air than in the Water, which is inscribed by the Glass, and above the Water, and rather in the Water than in the Glass: The agitation, or the trembling of the parts of the Glass to the sense appears not: for it is a continued Body; if in part, why then not in the whole? and that the Water turns in the Glass, this appears not; but onely the upper contiguous parts of the Water; that at the bottom being less subject to this agitation: and it is most certain that by how much quicker the Circular Motion of the Finger upon

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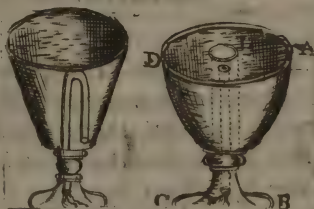
the edge of the Glass is, by so much the more shall the Air be agitated, and so the Water shall receive some apparent Affection more or less from it, according to that motion: as we see from the quickness of wind upon the Sea, or calm thereof, that there is a greater or lesser agitation in the Water; and for farther Examination, we leave it to the search of those which are Curious.

PROBLEM XXXVIII.

Of a fine Vessel which holds Wine or Water, being cast into it at a certain height, but being filled higher, it will run out of its own accord

LET there be a Vessel A B C D, in the middle of which place a Pipe, whose ends both above at E, and below at the bottom of the Vessel, as at F, are open; let the end E be somewhat lower than the brim of the Glass: about this Pipe place another Pipe, as H L, which mounts a little above E, and let it most diligently be closed at H, that no Air enter in thereby, and this Pipe at the bottom may have a small hole to give passage unto the Water; then pour in Water or Wine, and as long as it mounts not above E, it is safe; but if you pour in the Water so that it mount above it, farewell all, for it will not cease until it be all gone out; the same may be done in disposing any crooked Pipe in a Vessel in the manner of a Faucet or Funnel, as in the Figure H;

H; for fill it under H at pleasure, and all will go well; but if you fill it unto H you will see fine sport, for then all the Vessel will be empty incontinent, and the subtilty of this will seem more admirable, if you conceal the Pipe by a



Bird, Serpent, or such-like, in the middle of the Glass. Now the reason of this is not difficult to those which know the nature of a Cock or Faucet: for it is a bowed Pipe, one end of which is put into the water or liquor, and sucking at the other end until the Pipe be full, then will it run of it self, and it is a fine Secret in Nature to see, that if the end of the Pipe which is out of the water, be lower than the water, it will run out without ceasing; but if the Mouth of the Pipe be higher than the water, or level with it, it will not run, although the Pipe which is without be many times bigger than that which is within the water: for it is the property of Water to keep always exactly level.

Exami-

Examination.

Here is to be noted, that if the face of the Water without be in one and the same Plain with that which is within, though the outermost Pipe be ten times greater than that which is within, the Water naturally will not run; but if the Plain of the Water without, be any part lower than that which is within, it will freely run. And here may be noted further, that if the Mouth of the Pipe which is full of Water doth but onely touch the Superficies of the Water within, although the other end of the Pipe without be much lower than that within the Water, it will not run at all; which contradicts the first ground: Hence we gather that the pressure or ponderosity of the Water within, is the cause of running in some respect.

PROBLEM XXXIX.

Of a Glass very pleasant.

Sometimes there are Glasses which are made of a double fashion, as if one Glass were within another, so that they seem but one, but there is a little space between them. Now pour Wine or other Liquor between the two edges by help

help of a Tunnel, into a little hole left to this end, so will there appear two fine delusions or fallacies; for though there be not a drop of Wine within the hollow of the Glass, it will seem to those which behold it that it is an ordinary Glass full of Wine, and that especially to those which are sidewise of it; and if any one move it, it will much confirm it, because of the motion of the Wine; but that which will give most delight, is, that if any one shall take the Glass, and putting it to his mouth shall think to drink the Wine, instead of which he shall sup the Air, and so will cause laughter to those that stand by, who being deceived, will hold the Glass to the light, and thereby considering that the Rayes or Beams of the Light are not reflected to the Eye, as they would be, if there were a liquid substance in the Glass, hence they have an assured proof to conclude that the hollow of the Glass is totally empty.

PROBLEM XL.

If any one should hold in each hand as many pieces of money as in the other, how to find how much there is.

BId him that holds the money that he put out of one hand into the other what number you think convenient, (provided that it may be done) this done, bid him that out of the hand that he put the other number into, that he take out
of

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of it as many as remain in the other hand and put it into that hand : for then be assured that in the hand which was put the first taking away, there will be found just the double of the Number taken away at the first. *Example*: Admit there were in each hand 12 Shillings or Counters, and that out of the right hand you bid him take 7, and put it into the left : and then put into the right hand from the left as many as doth remain in the right, which is 5, so there will be in the left hand 14, which is the double of the number taken out of the right hand, to wit 7, then by some of the Rules before-delivered, it is easie to find how much is in the right hand, viz. 10.

PROBLEM XLI.

Many Dice being cast, how artificially to discover the number of the points that may arise.

Suppose any one had cast three Dice secretly, bid him that he add the points that were upmost together : then putting one of the Dice apart unto the former sum add the points which are under the other two, then bid him throw these two Dice, and mark how many points a pair are upwards, which add unto the former sum : then put one of these Dice away, not changing the side, mark the points which are under the other Dice, and add it to the former sum : lastly, throw that one Dice, and whatsoever appears upward add it unto the former sum, and let the Dice remain thus ;

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thus : this done, coming to the Table, note what points do appear upward upon the 3 Dice, which add privately together, and unto it add 21, or 3 times 7 : so this Addition or sum shall be equal to the sum which the party privately made of all the operations which he formerly made. As if he should throw 3 Dice, and there should appear upward 5, 3, 2, the sum of them is 10, and setting one of them apart, (as 5) unto 10 add the points which are under 3 and 2, which is 4 and 5, and it makes 19 ; then casting these 2 Dice, suppose there should appear 4 and 1, this added unto 19 makes 24, and setting 1 of these 2 Dice apart, as the 4 unto the former 24, I add the number of points which is under the other Dice, *viz.* under 1, that is 6, which makes 30. Last of all, I throw that 1 Dice, and suppose there did appear 2, which I add to the former 30, and it makes 32, then leaving the 3 Dice thus, the points which are upward will be these, 5, 4, 2, unto which add secretly 21, (as before was said) so have you 32, the same number which he had ; and in the same manner you may practice with 4, 5, 6, or many Dice or other Bodies, observing onely that you must add the points opposite of the Dice, for upon this depends the whole demonstration or secret of the play ; for alway that which is above and underneath makes 7 : but if it make another number, then must you add as often that number.

PRO-

PROBLEM XLII.

Two Metals, as Gold and Silver, or of other kind, weighing alike, being privately placed into two like Boxes, to find which of them the Gold or Silver is in.

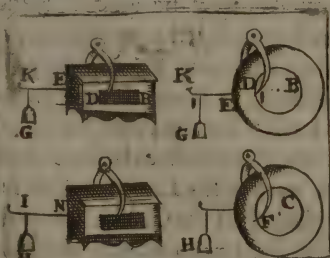
IT is said that an Emperour was requested by one of his Servants, after he had long time remained with him, to assign him some Reward : to which after a few days the Emperour condescended, and caused him to come into his Treasury, where he had prepared two Boxes, one full of Gold, and the other full of Lead, both weighing, and of form and magnitude alike : and bid him chuse which he would have. Now many think that in this Problem one must be guided only by Fortune in this Choice, and it is that which most makes a man happy in such a Choice : but the want of knowledge causeth them so to judge which know not otherwise. A Mathematician accounts it an easie Proposition, and will infallibly chuse the Chest of Gold, and leave the Chest of Lead, without either breaking or opening any of the Chests, and not go by chance and fortune : for if he may be permitted to weigh those Chests first in the Air, then in the Water, it is a thing clear by the proportion of Metals, and according to the Principles of *Archimedes* that the Gold shall be less weighty by his eighteenth part

part, and the Lead by his eleventh part, wherefore there may be gathered in which is the Gold, and in which is the Lead.

But because that this experiment in Water hath divers Accidents, and therefore subject to a caution; and namely because the matter of the Chest, metal, or other things, may hinder.

Behold here a more subtil and certain invention to find and discover it out, without weighing it in the Water: Now Experience and Reason sheweth us, that two like Bodies or Magnitudes of equal weight, and of divers Metals, are not of e-

qual quantity: and seeing that Gold is the heaviest of all Metals, it will occupy less room or place, from which will follow



that the like weight of Lead in the same form, will occupy or take up more room or place. Now let there be therefore presented two Globes or Chests of Wood, or other matter alike, and equal one to the other, in one of which in the middle there is another Globe or body of Lead weighing 12 pound, (as C) and in the other a Globe or like body of Gold weighing 12 pound (as B.) Now it is supposed that the Wooden Globes or Chests are of equal weight, form, and Magnitude: and to discover which the Gold or Lead is in, take a broad

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broad pair of Compasses, and clip one of the Coffers or Globes somewhat from the middle, as at D; then fix in the Chest or Globe a small piece of Iron between the feet of the Compasses, as E K, at the end of which hang a weight G, so that the other end may be counterpoysed, and hang in *equilibrio*: and do the like to the other Chest or Globe. Now if that the other Chest or Globe being clipped in like distance from the end, and hanging at the other end the same weight G, there be found no difference, then clip them nearer towards the middle, that so the points of the Compass may be against some of the Metal which is inclosed; or just against the extremity of the Gold as in D, and suppose it hang thus in *equilibrio*, it is certain that in the other Coffer is the Lead; for the points of the Compasses being advanced as much as before, as at F, which takes up a part of the Lead (because it occupies a greater place than the Gold) therefore that shall help the Weight G to weigh, and so will not hang in *equilibrio*, except G be placed near to F. Hence we may conclude that there is the Lead; and in the other Chest or Globe there is the Gold.

Examina

Examination.

IF the two Boxes being of equal magnitude weighed in the Air be found to be of equal weight, they shall necessarily take up like place in the Water, and therefore weigh also one as much as another : Hence there is no possibility to find the Inequality of the Metals which are inclosed in these Boxes in the Water : the intention of Archimedes was not upon contrary Metals inclosed in equal Boxes, but consisted of comparing Metals, simple in the Water one with another. Therefore the Inference is false and absurd.

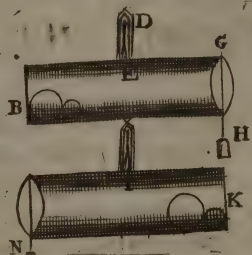
PROBLEM XLIII.

Two Globes of diverse Metals, (as one Gold, and the other Copper) yet of equal weight, being put into a Box, as B G, to find in which end the Gold or Copper is.

THis is discovered by the changing of the places of the two Bowles or Globes, having the same Counterpoise H to be hung at the other side, as in N; and if the Gold which is the lesser Globe, were before the nearest to the handle D E, having now changed his place, will be farthest from the handle D E, as in K ;
F there-

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therefore the Centre of Gravity of the two Globes taken together, shall be farther separate from the



middle of the handle (under which is the Centre of Gravity of the Box) than it was before, and seeing that the handle is always in the middle of the Box, the weight N must be augmented, to keep

it in *equilibrio*: and by this way one may know, that if at the second time, the counterpoise be too light, it is a sign that the Gold is farthest off the handle, as at the first trial it was nearest.

PROBLEM XLIV.

How to represent divers sorts of Rainbows here below.

THe Rainbow is a thing admirable in the World, which ravisheth often the Eyes and Spirits of men in consideration of its rich intermingled colours which are seen under the Clouds, seeming as the glistering of the Stars, precious Stones, and Ornaments of the most beauteous Flowers: some part of it as the resplendent Stars, or as a Rose, or burning Cole of fire, in it one may see Dyes of sundry sorts, the Violet, the

Blew,

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Blew, the Orange, the Saphir, the Jacinct, and the Emerald colours, as a lively plant placed in a green Soil : and as a most rich Treasure of Nature, it is a high work of the Sun who casteth his Rays or Beams as a curious Painter draws strokes with his Pencil, and placeth his Colours in an exquisite situation ; and *Solomon* saith, *Eccles.* 4. 3. It is a chief and principal Work of God. Notwithstanding there is left to industry how to represent it from above here below, though not in perfection, yet in part, with the same intermixture of colours that is above.

Have you not seen how by Oars of a Boat it doth exceeding quickly glide upon the Water with a pleasant grace ? *Aristotle* says, that it coloureth the Water, and makes a thousand atoms, upon which the Beams of the Sun reflecting, make a kind of coloured Rainbow : Or may we not see in Houses or Gardens of pleasure Artificial Fountains, which pour forth their droppey Streams of Water, that being between the Sun and the Fountain, there will be presented as a continual Rainbow ? But not to go farther, I will shew you how you may do it at your Door, by a fine and facil Experiment.

Take Water in your Mouth, and turn your Back to the Sun, and your Face against some obscure place, then blow out the Water which is in your Mouth, that it may be sprinkled in small Drops and Vapours : You shall see those Atomes Vapours in the Beams of the Sun to turn into a fair Rainbow, but all the grief is, that it lasteth not, but soon is vanished.

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But to have one more stable and permanent in his colours : Take a Glass full of Water, and expose it to the Sun, so that the Rays that pass through strike upon a shadowed place, you will have pleasure to see the fine form of a Rainbow by this reflection. Or take a Trigonal Glass or Crystal Glass of divers Angles, and look through it, or let the Beams of the Sun pass through it ; or with a Candle let the Appearances be received upon a shadowed place : you will have the same contentment.

PROBLEM XLV.

How that if all the Powder in the world were inclosed within a Bowl of Paper or Glass, and being fired on all parts, it could not break that Bowl.

IF the Bowl and the Powder be uniform in all his parts, then by that means the Powder would press and move equally on each side, in which there is no possibility whereby it ought to begin by one side more than another. Now it is impossible that the Bowl should be broken in all its parts, for they are infinite.

Of like fineness or subtilty may it be that a Bowl of Iron falling from a high place upon a plain pavement of thin Glass, it were impossible any wise to break it ; if the Bowl were perfectly round, and the Glass flat and uniform in all his parts : for the Bowl would touch the Glass
but

but in one point, which is in the middle of infinite parts which are about it : neither is there any cause why it ought more on one side than on another, seeing that it may not be done with all his sides together ; it may be concluded as speaking naturally, that such a Bowl falling upon such a Glass will not break it. But this matter is meer Metaphysical, and all the Workmen in the world cannot ever with all their Industry make a Bowl perfectly round, or a Glass uniform.

PROBLEM XLVI.

To find a number which being divided by 2, there will remain 1 ; being divided by 3, there will remain 1 ; and so likewise being divided by 4, 5, or 6, there would still remain 1 ; but being divided by 7, there will remain nothing.

IN many Authors of Arithmetick this Problem is thus proposed : A Woman carrying Egges to market in a Basket, met an unruly fellow who broke them, who was by order made to pay for them : and she being demanded what number she had, she could not tell : but she remembered that counting them by 2 and 2, there remained 1 ; likewise by 3 and 3, by 4 and 4, by 5 and 5, by 6 and 6 ; there still remained 1,

F 3

but

but when she counted them by 7 and 7, there remained nothing: Now how may the number of Eggs be discovered?

Find a Number which may exactly be measured by 7, and being measured by 2, 3, 4, 5, and 6, there will still remain a unite; multiply these numbers together, makes 720, to which add 1, so have you the number, *viz.* 721. In like manner 301 will be measured by 2, 3, 4, 5, 6; so that 1 remains: but being measured by 7, nothing will remain; to which continually add 220, and you have other numbers which will do the same: Hence it is doubtful what number she had. Therefore not to fail, it must be known whether they did exceed 400, 800, &c. in which it may be conjectured that it could not exceed 4 or 5 hundred, seeing a Man or Woman could not carry 7 or 8 hundred Eggs, therefore the number was the former 301, which she had in her Basket: which being counted by 2 and 2, there will remain 1, by 3 and 3, &c. but counted by 7 and 7, there will remain nothing.

PROBLEM XLVII.

One had a certain number of Crowns, and counting them by 2 and 2, there rested 1; counting them by 3 and 3, there rested 2; counting them by 4 and 4, there rested 3; counting them by 5 and 5, there rested 4; counting them by 6 and 6, there rested 5; but counting them by 7 and 7, there remained nothing: How many Crowns might he have?

THis Question hath some affinity to the precedent, and the Resolution is almost in the same manner: for here there must be found a number, which multiplied by 7, and then divided by 2, 3, 4, 5, 6, there may always remain a number less by 1 than the Divisor: Now the first number which arrives in this nature is 119, unto which if 420 be added, makes 539, which also will do the same: and so by adding 420, you may have other numbers to resolve this proposition.

PROBLEM XLVIII.

How many sorts of Weights in the least manner must there be to weigh all sorts of things between 1 pound and 40 pound, and so unto 121, & 364 pound.

TO weigh things between 1 & 40, take numbers in tripple proportion, so that their sum be equal, or somewhat greater than 40, as are the numbers 1, 3, 9, 27, I say that with 4 such Weights, the first being of 1 pound, the second being 3 pound, the third being 9 pound, and the fourth being 27: any weight between 1 & 40 pound may be weighed. As admit to weigh 21 pound, put unto the thing that is to be weighed the 9 pound weight, then in the other Ballance put 27 pound and 3 pound, which doth counterpoise 21 pound and 9 pound, and if 20 pound were to be weighed, put to it in the Ballance 9 and 1, and in the other Ballance put 27 and 3, and so of others.

In the same manner take those 5 Weights, 1, 3, 9, 27, 81, you may weigh with them between 1 pound, and 121 pound: and taking those 6 Weights, as 1, 3, 9, 27, 81, 243, you may weigh even from 1 pound unto 364 pound. This depends upon the property of continued Proportionals, the latter of which containing twice all the former.

PRO-

PROBLEM XLIX.

Of a deceitful Ballance, which being empty seems to be just, because it hangs in equilibrio : notwithstanding putting 12 pound in one Ballance, and 11 in the other, it will remain in equilibrio.

Aristotle mentioneth of this Ballance in his Mechanick Questions, and saith, That the Merchants of purpose in his time used them to deceive the World : the subtilty or craft of which is thus, that one arm of the Ballance is longer than another, by the same proportion that one weight is heavier than another : As if the Beam were 23 inches long, and the handle placed so that 12 inches should be on one side of it, and 11 inches on the other side : Conditionally that the shorter end should be as heavy as the longer, a thing easie to be done : then afterwards put into the ballance two unequal weights in such proportion as the parts of the beam have one unto another, which is 12 to 11, but so that the greater be placed in the ballance which hangs upon the shorter part of the Beam, and the lesser weight



weight in the other ballance : it is most certain that the ballances will hang *in equilibrio*, which will seem most sincere and just ; though it be most deceitful, abominable, and false.

The reason of this is drawn from the Experiments of *Archimedes*, who shews that two unequal weights will counterpoise one another, when there is like proportion between the parts of the Beam (that the handle separates) and the Weights themselves : for in one and the same counterpoise, by how much it is farther from the Centre of the Handle, by so much it seems heavier ; therefore if there be a diversity of distance that the Ballances hang from the handle, there must necessarily be an inequality of weight in these Ballances to make them hang in *equilibrio* ; and to discover if there be deceit, change the Weight into the other Ballance : for as soon as the greater Weight is placed in the Ballance that hangs on the longer parts of the Beam, it will weigh down the other instantly.

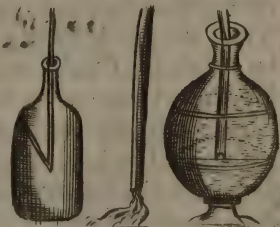
PROBLEM L.

To heave or lift up a Bottle with a Straw.

TAKE a Straw that is not bruised, bow it that it make an Angle, and put it into the Bottle so that the greatest end be in the Neck, then the Reed being put in the bowed part will cast sideways, and make an Angle, as in the figure may

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may be seen : then may you take the end which is out of the Bottle in your hand, and heave up the Bottle, and it is so much surer, by how much the Angle is acuter or sharper; and the end which is bowed approacheth to the other perpendicular parts which come out of the Bottle.



PROBLEM LI.

How in the middle of a Wood or Desert, without the sight of the Sun, Stars, Shadow, or Compass, to find out the North or South, or the four Cardinal Points of the World, East, West, &c.

IT is the Opinion of some, that the Winds are to be observed in this : if it be hot, the South is found by the winds that blow that way, but this Observation is uncertain, and subject to much Error : Nature will help you in some measure to make it more manifest than any of the former, from a Tree, thus : Cut a small Tree off, even to the ground, and mark the many Circles that are about the sap or pith of the Tree, which seem nearer together in some part than in other, which is by reason of the Suns motion about the Tree : for that the humidity of the parts of the Tree

Tree towards the South by the heat of the Sun is rarified, and caused to extend : and the Sun not giving such heat towards the North part of the Tree, the Sap is lesser rarified, but condensed ; by which the Circles are nearer together on the North part than on the South part : therefore if a Line be drawn from the widest to the narrowest part of the Circles, it shall shew the North and South of the World. Another Experiment may be thus : Take a small Needle, such as Women work with : place it gently down flat-wise upon still

Water, and it will not sink, (which is against the general Tenet that Iron will not swim) which Needle will by little and little turn to the North and South points. But if the Needle be great, and will not swim, thrust it through a small piece of Cork, or some such-like thing, and then it will do the same : for such is the property of Iron when it is placed in *aequilibrio*, it strives to find out the Poles of the World, or Points of North and South in a manner as the *Magnet* doth.



Examini-

Examination.

HERE is observable, that the moisture which addeth to the growth of the Tree, is dilated and rarified by the Meridional heat, and contracted by the Septentrional cold: this Rarefaction works upon the part of the humour or moisture that is more thin, which doth easily dissipate and evaporate: Which evaporation carries a part of the Salt with it; and because that Solidation or Condensation, so that there is left but a part of the Nourishment which the heat bakes up and consumes: so contrarily on the other side the Condensation and Restrictive Quality of the Moisture causeth less Evaporation and Perdition: and so consequently there remains more Nourishment, which makes a greater increase on that side than on the other side: for as Trees have their growth in Winter, because of their Pores, and these of the Earth are shut up: so in the Spring, when their Pores are open, and when the Sap and Moisture is drawn by it, there is not such Cold on the North side that it may be condensed at once: But contrarily to the side which is South, the heat may be such, that in little time by continuance, this moisture is dissipated greatly: And Cold is nothing but that which hardeneth and contracteth the moisture of the Tree, and so converteth it into Wood.

PRO-

PROBLEM LII.

Three Persons having taken Counters, Cards, or other things, to find how much each one hath taken.

CAuse the third party to take a number which may be divided by 4, and as often as he takes four, let the second party take 7, and the first take 13, then cause them to put them all together, and declare the sum of it; which secretly divide by 3, and the Quotient is the double of the number which the third person did take. Or cause the third to give unto the second and first, as many as each of them hath; then let the second give unto the first and third, as many as each of them hath; lastly, let the third give unto the second and first, as many as each of them hath; and then ask how much one of them hath: (for they will have then all alike) so half of that number is the number that the third person had at the first; which known, all is known.

PROBLEM LIII.

How to make a Consort of Musick of many parts, with one Voice, or one Instrument onely.

THIS Problem is resolved, so that a Singer or Player upon an Instrument, be near an Echo which answereth his Voice or Instrument; and if the

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the Echo answereth but once at a time, he may make a double; if twice, then a tripple; if three times, then an harmony of four parts: for it must be such a one that is able to exercise both tune and note, as occasion requires. As when he begins *ut*, before the Echo answer, he may begin *sol*, and pronounce it in the same tune that the Echo answereth, by which means you have a fifth agreeable Consort of Musick: then in the same time that the Echo followeth, to sound the second note *sol*, he may sound forth another *sol* higher or lower, to make an eight, the most perfect Consort of Musick, and so of others, if he will continue his Voice with the Echo, and sing alone with two parts. Now Experience sheweth this to be true, which often comes to pass in many Churches, making one to believe that there are many more parts in the Musick of a Quire, than in effect truly there are, because of the resounding and multiplying of the Voice, and redoubling of the Quire.

PROBLEM LIV.

To make or describe an Oval form, or that which near resembles unto it, at one turning with a pair of common Compasses.

There are many fine ways in Geometrical practices, to make an Oval Figure, or one near unto it, by several Centres: any of which I will not touch upon, but shew how it may be done promptly

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promptly upon one Centre onely. In which I will say nothing of the Oval form, which appears, when one describeth Circles with the points of a common Compass, somewhat deep upon a Skin stretched forth hard : which contracting it self in some parts of the Skin maketh an Oval form. But it will more evidently appear upon a Column or Cylinder : if Paper be placed upon it, then with a pair of Compasses describe as it were a Circle upon it, which Paper afterwards being extended, will not be circular, but oval-wise : and a pair of Compasses may be so accommodated, that it may be done also upon a Plain thus : As let the length of the Oval be H K, fasten 2 Pins or Nails near the end of that Line, as F G, and take a thread which is double to the length of GH, or FK, then if



you take a Compass which may have one foot lower than another, with a Spring between his legs, and placing one foot of this Compass in the Centre of the Oval, and guiding the thred by the other foot of the Compasses, and so carrying it about : the Spring will help to describe and draw the Oval form. But instead of the Compasses it may be done with ones hand only, as in the Figure may appear.

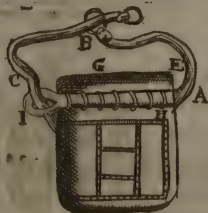
PRO-

PROBLEM LV.

Of a Purse difficult to be opened.

IT is made to shut and open with Rings: first at each side there is a strap or string, as *A B* and *C D*, at the end of which are 2 Rings, *B* and *D*, and the string *C D* passeth through the Ring *B*, so that it may not come out again, or be parted one from another: and so that the Ring *B* may slide up and down upon the string *C D*, then over the purse there is a piece of Leather *E F G H*, which covers the opening of the purse, and there is another piece of Leather *A E*, which passeth thro-

row many Rings, which hath a slit towards the end *I*, so great that the string *B C* may slide into it: Now all the cunning or craft is how to make fast or to open the purse, which consists in making



the string *B C* slide through the side at *I*, therefore bring down *B* to *I*, then make the end *I* pass thro- row the ring *B*, and also *D* with his string to pass through the slit *I*, so shall the Purse be fast, and then may the strings be put as before, and it will seem difficult to discover how it was done. Now to open the Purse, put through the end *I* through the Ring *B*, and then through the slit *I*, by which you put through the String *D C*, by this way the Purse will be opened.

PROBLEM LVI.

Whether it is more hard and admirable, without Compasses to make a perfect Circle, or being made, to find out the Centre of it.

IT is said that upon a time past, two Mathematicians met, and they would make trial of their Industry: The one made instantly a Perfect Circle without Compasses, and the other immediately pointed out the Centre thereof with the point of a Needle: Now which is the chiefeſt Action? It ſeems the firſt, for to draw the moſt nobleſt Figure upon a Plain Table without other help than the Hand and the Mind, is full of admiration; to find the Centre is but to find out onely one point, but to draw a Round, there muſt be almoſt infinite points, equidiſtant from the Centre or middle; that in Concluſion it is both the Circle and the Centre together. But contrarily it may ſeem that to find the Centre is more difficult: for what attention, vivacity, and ſubtilty muſt there be in the Spirit, in the Eye, in the Hand, which will chuſe the true point amongſt a thouſand other points? He that makes a Circle keeps always the ſame diſtance, and is guided by a half diſtance to finiſh the reſt; but he that muſt find the Centre, muſt in the ſame time take heed to the parts about it, and chooſe one onely point which is equally diſtant from an infinite of other

other points which are in the Circumference ; which is very difficult. *Aristotle* confirms this amongst his Morals, and seems to explain the difficulty which is to be found in the middle of Virtue ; for it may want a thousand ways, and be far separated from the true Centre of the end of a right Mediocrity of a vertuous Action : for to do well, it must touch the middle point, which is but one, and there must be a true point which respects the end, and that's but one onely. Now to judge which is the most difficult, as before is said, either to draw the Round, or to find the Centre, the Round seems to be harder than to find the Centre, because that in finding of it is done at once, and hath an equal distance from the whole ; But, as before, to draw a Round, there is a visible point imagined, about which the Circle is to be drawn. I esteem that it is as difficult therefore, if not more, to make the Circle without a Centre, as to find the middle or Centre of that Circle.

PROBLEM LVII.

Any one having taken 3 Cards, to find how many points they contain.

THis is to be exercised upon a full Pack of Cards of 52, then let one choose any three at pleasure secretly from your sight, and bid him secretly account the points in each Card, and will him to take as many Cards as will make up 15 to

each of the points of his Cards, then will him to give you the rest of the Cards, for 4 of them being rejected, the rest shew the number of points that his three Cards which he took at the first did contain. As if the 3 Cards were 7, 10, and 4; now 7 wants of 15, 8; take 8 Cards therefore for your first Card: the 10 wants of 15, 5; take 5 Cards for your second Card: lastly, 4 wants of 15, 11; take 11 Cards for your third Card, and giving him the rest of the Cards there will be 25; from which take 4, there remains 21, the number of the three Cards taken, viz. 7, 10, and 4.

Whosoever would practise this play with 4, 5, 6, or more cards, and that the whole number of cards be more or less than 52; and that the term be 15, 14, 12, &c. this general Rule ensuing may serve: multiply the term by the number of cards taken at first; to the product add the number of cards taken, then subtract this sum from the whole number of cards; the remainder is the number which must be subtracted from the cards, which remains to make up the Game: if there remain nothing after the subtraction, then the number of cards remaining doth justly shew the number of points which were in the cards chosen. If the subtraction cannot be made, then subtract the number of cards from that number, and the remainder added unto the cards that did remain, the sum will be the number of points in the cards taken, as if the cards were 7, 10, 5, 8, and the term given were 12; so the first wants 5, the second wants 2, the third wants 7, and the fourth wants 4 cards, which taken, the party gives you the

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the rest of the cards: then secretly multiply 12 by 4, makes 48; to which add 4, the number of cards taken makes 52, from which 52 should be taken, rest nothing: therefore according to the direction of the remainder of the cards, which are 30, is equal to the points of the four cards taken, viz. 7, 10, 5, 8. Again, let these 5 cards be supposed to be taken, 8, 6, 10, 3, 7; their differences to 15, the terms are 7, 9, 5, 12, 8, which number of cards taken, there will remain but 6 cards: then privately multiply 15 by 5, makes 75, to which add 5 makes 80, from this take 52, the number of cards, rests 28, to which add the remainder of cards, makes 34, the sum with 8, 6, 10, 3, 7.

PROBLEM LVII.

Many Cards placed in divers ranks, to find which of these Cards any one hath thought.

TAKE 15 Cards, and place them in 3 heaps in rank-wise, 5 in a heap: now suppose any one had thought one of these Cards in any one of the heaps, it is easie to find which of the Cards it is, and it is done thus: ask him in which of the heaps it is, which place in the middle of the other two; then throw down the Cards by 1 and 1 into three several heaps in rank-wise, until all be cast down, then ask him

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in which of the ranks his Card is, which heap place in the middle of the other two heaps always, and this do four times at least, so in putting the Cards altogether, look upon the Cards, or let their back be towards you, and throw out the eight Card, for that was the Card thought upon without fail.

PROBLEM LVIII.

Many Cards being offered to sundry Persons, to find which of these Cards any one thinketh upon.

ADmit there were 4 persons, then take 4 Cards and shew them to the first, bid him think one of them, and put these 4 away; then take 4 other Cards, and shew them in like manner to the second person, and bid him think any one of these Cards, and so do to the third person, and so the fourth, &c. Then take the 4 Cards of the first person, and dispose them in 4 ranks, and upon them the 4 Cards of the second person, upon them also these of the third person, and lastly, upon them these of the fourth person; then shew unto each of these parties each of these ranks, and ask him if his Card be in it which he thought, for infallibly that which the first party thought upon will be in the first rank, and at the bottom the Card of the second person will be in the second rank, the Card of the third thought upon will be in the third rank, and the fourth

mans

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mans Card will be in the fourth rank, and so of others; if there be more persons, use the same method. This may be practised by other things, ranking them by certain numbers allotted to pieces of money, or such-like things.

PROBLEM LIX.

How to make an Instrument to help Hearing, as Galileus made to help the Sight.

THink not that the Mathematicks (which hath furnished us with such admirable helps for Seeing) is wanting for that of Hearing; it's well known that long Trunks or Pipes make one hear well far off, and Experience shews us that in certain places of the *Orcades* in a hollow vault, that a man speaking but softly at one corner thereof, may be audibly understood at the other end: notwithstanding those which are between the parties cannot hear him speak at all: and it is a general Principle, that Pipes do greatly help to strengthen the Activity of Natural Causes: We see that fire contracted in a Pipe, burns 4 or 5 foot high, which would scarce heat, being in the open air: the rupture or violence of water issuing out of a Fountain, shews us that water being contracted into a Pipe, causeth a violence in its passage. The Glasses of *Galileus* makes us see how useful Pipes

or Trunks are to make the Light and Species more visible and proportionable to our Eye. It is said that a Prince of *Italy* hath a fair Hall, in which he can with facility hear distinctly the Discourses of those which walk in the adjacent Gardens, which is by certain Vessels and Pipes that answer from the Garden to the Hall. *Viruvius* makes mention also of such Vessels and Pipes to strengthen the Voice and Action of *Comedians*: and in these times amongst many Noble Personages, the new kind of Trunks are used to help the hearing, being made of Silver, Copper, or other resounding material; in funnel-wise putting the widest end to him which speaketh, to the end to contract the Voice, that so by the Pipe applied to the Ear it may be more uniform, and less in danger to dissipate the Voice, and so consequently more fortified.

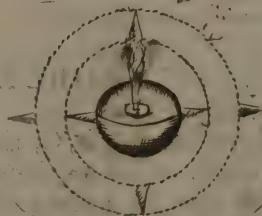
PROBLEM LX.

Of a fine Lamp which goes not out, though one carry it in ones pocket.: or being rolled upon the ground will still burn.

IT must be observed that the Vessel in which the Oil is put into, have two pins on the sides of it, one against another, being included within a circle: this circle ought to have two other pins, to enter into another circle of brass, or other solid matter: lastly, this second circle hath two pins

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pins, which may hang within some Box to contain the whole Lamp, in such manner, that there be six pins in different position : Now by the aid of these pegs or pins, the Lamp that is in the middle will be always well situated according to his Centre of Gravity, though it be turned any way : though if you endeavour to turn it upside-down, it will lie level : which is pleasant and admirable to behold to those which know not the cause.



And it is facil from this to make a place to rest quiet in, though there be great agitation in the outward parts.

PROBLEM LXI.

Any one having thought a Card amongst many Cards, how artificially to discover it out.

TAKE any number of cards, as 10, 12, &c. and open some four or five to the parties sight, and bid him think one of them, but let him note whether it be the first, second, third, &c. then with promptness learn what number of Cards you had in your hands, and take the other part of the Cards, and place them on the top of these you hold in your hand ; and having done so,

So, ask him whether his Card were the first, second, &c. then before knowing the number of Cards that were at the bottom, account backwards until you come to it : so shall you easily take out the Card that he thought upon.

PROBLEM LXII.

Three Women, A, B, C, carried Apples to a Market to sell, A had 20, B 30, and C 40 ; they sold as many for a penny the one as the other, and brought home one as much money as another : How could this be ?

THE Answer to the Problem is easie : As suppose at the beginning of the Market, A sold her Apples at a penny an Apple, and sold but two, which was two pence, and so she had 18 left :

$$\begin{array}{r} 20 \\ 2 \\ \hline 18 \end{array} \quad \text{and} \quad \begin{array}{r} 18 \\ 3 \\ \hline 6 \end{array} \quad \text{is} \quad 24$$

$$\begin{array}{r} 30 \\ 3 \\ \hline 27 \end{array} \quad \text{and} \quad \begin{array}{r} 27 \\ 3 \\ \hline 9 \end{array} \quad \text{is} \quad 36$$

$$\begin{array}{r} 40 \\ 4 \\ \hline 36 \end{array} \quad \text{and} \quad \begin{array}{r} 36 \\ 4 \\ \hline 9 \end{array} \quad \text{is} \quad 45$$

but B sold 17, which was 17 pence, and so had 13 left : C sold 32, which was 32 pence, and so had 8 Apples left. Then A said she would not sell her Apples so cheap, but would sell them for 3 pence a piece, which she did, and so her Apples came to 54 pence : And B having left but 13 Apples, sold them at the same rate, which came to 39 pence :

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pence : And lastly, C had but 8 Apples, which at the same rate came to 24 pence : These sums of money which each others before received come to 56 pence, and so much each one received; and so consequently brought home one as much as another.

PROBLEM LXIII.

Of the Properties of Some Numbers.

First, any two numbers is just the sum of a number, that have equal distance from the half of that number : the one augmenting, and the other diminishing : as 7 and 7, of 8 and 6, of 9 and 5, of 10 and 4, of 11 and 3, of 12 and 2, of 13 and 1, as the one is more than the half, the other is less.

Secondly, It is difficult to find two numbers whose sum and product is alike, (that is) if the numbers be multiplied one by another, and added together, will be equal, which two numbers are 2 and 2, for to multiply 2 by 2 makes 4, and adding 2 unto 2 makes the same : this property is in no other two whole numbers, but in broken numbers there are infinite, whose sum and product will be equal one to another. As *Clavius* shews upon the 36 Prob. of the 9th Book of *Euclid*.

Thirdly,

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Thirdly, The numbers 5 and 6 are called circular numbers, because the circle turns to the point from whence it begins: so these numbers multiplied by themselves, do end always in 5 and 6, as 5 times 5 makes 25, that again by 5 makes 125, so 6 times 6 makes 36, and that by 6 makes 216, &c.

Fourthly, The number 6, is the first which Arithmeticians call a perfect number, that is, whose parts are equal unto it, so the sixth part of it is 1, the third part is 2, the half is 3, which are all his parts: now 1, 2, and 3, is equal to 6. It is wonderful to conceive that there is so few of them, and how rare these numbers are, so of perfect men: for betwixt 1 and 1000000000000 numbers there is but ten, that is, 6, 28, 486, 8128, 120816, 2096128, 33550336, 536854528, 8589869056, and 137438691328, with this admirable property, that alternately they end all in six and eight, and the Twentieth Perfect Number is 151115727451553768931328.

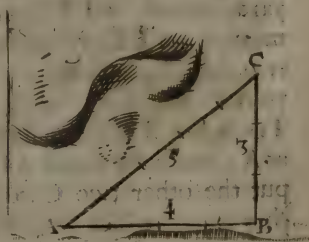
Fifthly, The number 9 amongst other privileged carries with it an excellent property; for take what number you will, either in gross or in part, the nines of the whole or in its parts rejected, and taken simply will be the same, as 27 it makes 3 times 9, so whether the nines be rejected of 27 or of the sum of 2 and 7, it is all one; so if the nines were taken away of 240, it is all one if the nines were taken away of 2, 4, and 0; for there would remain 6 in either; and so of others.

Sixthly,

Sixthly, 11 being multiplied by 2, 4, 5, 6, 7, 8, or 9, will end and begin with like numbers; so 11 multiplied by 5 makes 55, if multiplied by 8, it makes 88, &c.

Seventhly, the numbers 220 and 284 being unequal, notwithstanding the parts of the one number do always equalize the other number: so the *aliquot* parts of 220 are 110, 54, 44, 22, 20, 11, 10, 5, 4, 2, 1, which together makes 284, the *aliquot* parts of 284, are 142, 71, 4, 2, 1, which together makes 220, a thing rare and admirable, and difficult to find in other numbers.

Eightly, The numbers 3, 4 5, (found out by *Pythagoras*) have an excellent property in making of Rectangle Triangles: upon which the 47 *Pro.* of the first Book of *Euclid* was grounded, that the square of the *Hypothensal* in any such Triangle, is equal to the square of the other two sides: that is 5, the *Hypothensal* multiplied in 5 makes 25, and 4 multiplied in 4 makes 16, and 3 multipli'd in 3 makes 9, but 9 and 16 is equal to 25, or if these numbers 3, 4, 5, be doubled, *viz.* 6, 8,

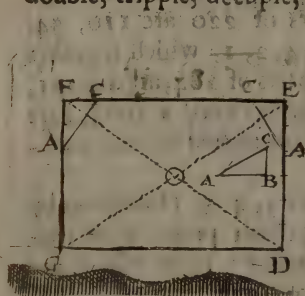


10: the square of 10 is equal to the square of 8 and 6, *viz.* 10 times 10 makes 100, and 8 times 8 makes 64, and 6 times 6 is 36; which

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36 and 64, put together makes 100, as before : and so may they be *Tripled, Quadrupled, &c.*

The use of these numbers 3, 4, 5, are manifold, but it may be applied thus, for the help of such which plot out Gardens, Houses, encamp Horse or Foot, &c. Example, take 3 Cords, one of 5 yards, another of 4 yards, and another of 3 yards, or the double, tripple, decuple, &c. or all in one line,



and make knots at the terms of these measures, so these three parts will make a right angled Triangle, as *A, B, C*; and it is easie with this Triangular Cord to plot out a Garden-

plat, or other long square. As suppose there is a figure, *E D F G* to be plotted, *E D* of 60 yards broad, and *FG* 100 yards long. First measure out *E D* 60 yards, and at *E* and *D* place two pins or pegs; then at *E* place the Angle of your Triangular Cord *B*, and let the line of the Triangle *A B* be in the line *E D*, which suppose at *A*; make the Cord *A B* fast in *E* and *A*, then put the other two Cords of the Triangle until they meet, which will be in *C*, and place a peg at *C*; take afterwards a long Cord, and by the points *E* and *C* augment it unto *F* 100 yards from *E*, and at *F* place a peg; then at *F* apply your Triangular Cord as you did at *E*, and so may you draw the line *FG* as long as *E D*, viz. 60 yards.

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yards. Lastly, it is easie to draw the Line GD , and so the Rectanguled Figure or Long Square shall be plotted, whose breadth is 60 yards, and length 100 yards, as was required: and to examine this, measure EG , then if FD be as long, the figure is true: otherwise it is defective, and may easily be amended.

If one be taken from any square number which is odd, the square of half of it being added to the first square, will make a square number.

The square of half any even number $+ 1$ being added to that even number makes a square number, and the even number taken from it leaves a square number.

If odd numbers be continually added from the unity successively, there will be made all square numbers, and if cubick numbers be added successively from the unity, there will be likewise made square numbers.

PROBLEM LXIV.

Of an Excellent Lamp, which serves or furnisheth it self with Oil, and burns a long time.

I Speak not here of a common Lamp which *Cardanus* writes upon in his Book *de subtilitate*, for that's a little Vessel in Columne-wise, which

which is full of Oyl, and because there is but one little hole at the bottom near the Week or Match, the Oil runs not, for fear that there be emptiness above: When the Match is kindled it begins to heat the Lamp, and rarifying the Oil it issueth by this occasion: and so sends his more airy parts above, to avoid vacuity.



But that which I here deliver is more ingenious, the principal piece of which is a vessel, as C D, which hath near the bottom a hole, and a funnel or pipe C, and then a bigger funnel, which passeth thro-

row the middle of the Vessel, having an opening at D near the E top, and another at the bottom, as at E, near the Vessel under it, so that the Pipe touch it not: the Vessel being thus made, fill it with Oyl, and opening the hole C, the Oil running out will stop the hole at E, or throwing in Oil into the Vessel underneath, until E be stopped; then the Oil at C will not run: because no air can come into the Pipe D E. Now as the Oil burneth and consumeth in the Vessel A B, the hole at E will begin to open, then immediately will C begin to run to fill up A B, and E being stopped with the Oil, the Oil at C ceaseth to run.

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It is certain that such a Lamp the *Athenians* used, which lasted a whole year without being touched : which was placed before the Statue of *Minerva*, for they might put a certain quantity of Oyl in the Lamp C D, and a match to burn without being consumed : such as the Naturalists write of, by which the Lamp will furnish it self, and so continue in burning : and here may be noted that the Oyl may be poured in at the top of the Vessel at a little hole, and then made fast again that the Air get not in.

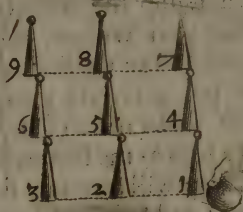
PROBLEM LXV.

Of the play at Keyles or Nine-Pins.

YOU will scarce believe that with one Bowl, and at one blow playing freely, one may strike down all the Keyles at once : yet from Mathematical Principles it is easie to be demonstrated, that if the hand of him that plays were so well assured by Experience as Reason induceth one thereto, one might at one blow strike down all the Keyls, or at least 7 or 8, or such a number as one pleaseth.

For they are but Nine in all, disposed or placed in a perfect Square, having Three every way. Let us suppose then that a good Player beginning to play at 1 somewhat low, should so strike it, that it should strike down the Keyles 2 and 5, and these might in their violence strike

H down



down the Keyles 3, 6, and 9, and the Bowl being in motion may strike down the Keyle 4, and 7; which 4 Keyle may strike the Keyl 8, and so all the 9 Keyles may be striken down at once.

PROBLEM LXIV.

Of Spectacles of pleasure.

Simple Spectacles of blew, yellow, red or green colour, are proper to recreate the sight, and will present the Objects died in like colour that the Glasses are, only those of the Green do somewhat degenerate; instead of shewing a lively colour, it will represent a pale dead colour, and it is because they are not died green enough, or receive not light enough for green: and colour these Images that pass through these Glasses unto the bottom of the Eye.

Examina=

Examination.

IT is certain, that not onely Glasses dyed green, but all other Glasses coloured, yield the appearances of Objects strong or weak in colour according to the quantity of the dye, more or less, as one being very yellow, another a pale yellow; now all colours are not proper to Glasses to give colour, hence the defect is not that they want faculty to receive light, or resist the penetration of the beams; for in the same Glasses those which are most dyed, give always the Objects more high-coloured and obscure, and those which are less dyed, give them more pale and clear: and this is daily made manifest by the painting of Glass, which hinders more the penetration of the light than dying doth, where all the matter by fire is forced into the Glass, leaving it in all parts transparent.

Spectacles of Crystal cut with divers Angles Diamond-wise, do make a marvellous multiplication of the appearances, for looking towards a House it becomes as a Town, a Town becomes like a City, an armed man seems as a whole Company, caused solely by the diversity of Refractions, for as many Plains as there are on the out side of the Spectacle, so many times will the Object be multiplied in the appearance, because of divers Images cast into the Eye. These are pleasurable Spectacles for avaritious persons that love Gold and Silver, for one Piece will seem many, or one

heap of Money will seem as a Treasury : but all the mischief is, he will not have his end in the enjoying of it, for endeavouring to take it, it will appear but a deceitful Image, or delusion of nothing. Here may you note, that if the finger be directed by one and the same ray or beam, which pointeth to one and the same object, then at the first you may touch that visible Object without being deceived : otherwise you may fail often in touching that which you see. Again, there are Spectacles made which do diminish the thing seen very much, and bring it to a fair perspective form ; especially if one look upon a fair Garden-plat, a greater Walk, a stately Building, or great Court ; the industry of an exquisite Painter cannot come near to express the lively form of it as this Glass will represent it ; you will have pleasure to see it really experimented ; and the cause of this is, that the Glasses of these Spectacles are hollow and thinner in the middle, than at the edges, by which the visual Angle is made lesser. : You may observe a further secret in these Spectacles, for in placing them upon a Window one may see those that pass to and fro in the Streets, without being seen of any ; for their property is to raise up the Objects that it looks upon.

Now I would not pass this Problem without saying something of Galileus admirable Glass : for the common simple perspective Glasses, give to Aged Men but the Eyes or sight of Young Men, but this of Galileus gives a Man an Eagles Eye, or an Eye that pierceth the Heavens : First it discovereth the spotty and shadowed opacous Bodies that are found about the Sun, which darkeneth and diminisheth the splendor of that beautiful and shining Luminary :

Secondly,

Secondly, It shews the New Planets that accompany Saturn and Jupiter : Thirdly, in Venus is seen the New, Full, and Quartile Increase; as in the Moon by her separation from the Sun : Fourthly, the artificial structure of this Instrument helpeth us to see an innumerable number of Stars, which otherwise are obscured, by reason of the natural weakness of our sight; yea the Stars in Via Lactea are seen most apparently; where there seem no Stars to be, this Instrument makes apparently to be seen, and further delivers them to the Eye in their true and lively colour, as they are in the Heavens, in which the splendor of some is as the Sun in his most glorious Beauty.

This Glass hath also a most excellent use in observing the Body of the Moon in time of Eclipses, for it augments it manifold, and most manifestly shews the true form of the cloudy substance in the Sun; and by it is seen when the shadow of the Earth begins to eclipse the Moon, and when totally she is overshadowed. Besides the Cœlestial Uses which are made of this Glass, it hath another Noble Property, it far exceedeth the ordinary Perspective Glasses, which are used to see things remote upon the Earth: For as this Glass reacheth up to the Heavens, and excelleth them there in his performance, so on the Earth it claimeth prebeminency, for the Objects which are farthest remote, and most obscure, are seen plainer than those which are near at hand, scorning as it were all small and trivial services, as leaving them to an inferior help: great use may be made of this Glass in discovering Ships, Armies, &c. Now the apparel or parts of this Instrument or Glass is mean

or simple, which makes it the more admirable (seeing it performs such great Service) having but a Convex Glass, thickest in the middle, to unite and amass the Rays, and make the Object the greater; to the augmenting the visual Angle, as also a Pipe or Trunk to amass the Species, and hinder the greatness of the light which is about it: (to see well, the Object must be well inlightened, and the Eye in obscurity) then there is adjoyned unto it a Glass of a short sight to distinguish the Rays, which the other would make more confused if alone. As for the proportion of those Glasses to the Trunk, though there be certain Rules to make them, yet it is often by hazard that there is made an excellent one, there being so many difficulties in the action; therefore many ought to be tried, seeing that exact proportion in Geometrical Calculation cannot serve for diversity of sights in the Observation.

PRO-

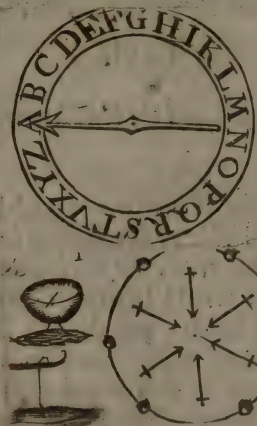
PROBLEM LXVII.

*Of the Adamant or Magnes, and the Needles touch-
ed therewith.*

W^HO would believe, if he saw not with his Eyes, that a Needle of Steel being once touched with the *Magnes*, turns not once, not a year, but as long as the World lasteth, his end towards the North and South; yea though one remove it, and turn it from its position, it will come again to his points of North and South? Who would have ever thought that a brute Stone, black and ill formed, touching a Ring of Iron, should hang it in the Air, and that Ring support a second, that to support a third, and so unto 10, 12, or more, according to the strength of the *Magnes*; making as it were a Chain without a Line, without fouldering together, or without any other thing to support them onely; but a most occult and hidden vertue, yet most evident in this effect, which penetrateth insensibly from the first to the second, from the second to the third, &c.

Is it not a wonder to see that a Needle touched once will draw other Needles; and so a Nail, the point of a Knife, or other pieces of Iron? Is it not a pleasure to see how the *Magnes* will turn File-dust, or move Needles, or Nails being upon a Table, or upon a piece of paper? For as soon as the *Magnes* turns or moves over, it moves

also: who is it that would not be ravished as it were to see a hand of Iron write upon a Plank, without seeing the *Magnet* which causeth that motion behind the Plank, or to make an Image of Iron to run up and down a Turret: now infinite of such inventions is proper to be extracted from the properties of the *Magnets*.



What is there in the World that is more capable to cast a deeper astonishment in our minds than a great massie substance of Iron to hang in the Air in the midst of a Building without any thing in the World touching it, but only the Air? As some Histories assure us that by the aid of a *Magnet* or Adamant, placed at the Roof of one of the Turkish Synagogues in *Meca*, the Sepulchre of that infamous *Mahomet* rests suspended in the Air; and *Pliny* in his Natural History writes that the Architector *Democrates* did begin to vault the Temple of *Arfinoe* in *Alexandria*, with store of *Magnets* to produce the like deceit, to hang the Sepulchre of that Goddeffs likewise in the air.

I should pass the bounds of my counterpoise, if I should divulge all the secrets of this Stone, and

and should expose my self to the laughter of the World, if I should brag to shew others the cause how this appeareth, than in its own natural sympathy, for why is it that a *Magnes* with one end will cast the Iron away, and attract it with the other? From whence cometh it that all the *Magnes* is not proper to give a true touch to the Needle, but onely in the two Poles of the Stone: which is known by hanging the Stone by a thread in the air until it be quiet, or placed upon a piece of Cork in a Dish of Water, or upon some thin Board, for the Pole of the Stone will then turn towards the Poles of the World, and point out the North and South, and so shew by which of these ends the Needle is to be touched?

From whence comes it that there is a variation in the Needle, and pointeth not out truly the North and South of the World, but only in some place of the Earth?

How is it that the Needle made with pegs and inclosed within two Glasses, sheweth the height of the Pole, being elevated as many degrees as the Pole is above the Horizon?

What's the cause that Fire and Garlick takes away the Property of the *Magnes*? There are many great hidden Mysteries in this Stone, which have troubled the Heads of the most Learned in all Ages, and to this time the World remains ignorant of declaring the true cause thereof.

Some say, that by help of the *Magnes* persons which are absent may know each others mind,

mind, as if one being here at *London*, and another at *Prague* in *Germany*, if each of them had a Needle touched with one *Magnes*, then the virtue is such that in the same time that the Needle which is at *Prague* shall move, this that is at *London* shall also; provided that the parties have like secret Notes or Alphabets, and the observation be at a set hour of the day or night; and when the one party will declare unto the other, then let that party move the Needle to these Letters which will declare the matter to the other, and the moving of the other parties Needle shall open his intention.

The invention is subtile, but I doubt whether in the World there can be found so great a Stone, or such a *Magnes* which carries with it such virtue: neither is it expedient, for Treasons would be then too frequent and open.

Examination.

THe Experimental Difference of Rejection and Attraction proceeds not from the different Nature of Stones, but from the Quality of the Iron; and the virtue of the Stone consisteth onely and especially in his Poles, which being hanged in the Air turns one of his ends always naturally towards the South, and the other towards the North: but if a Rod of Iron be touched with one of the ends thereof, it hath the like property in turning North and South, as the *Magnes*

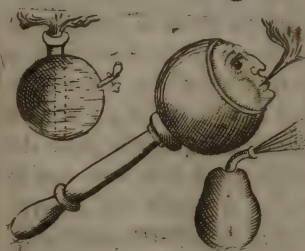
Magnes hath: Notwithstanding the end of the Iron Rod touched, hath a contrary position, to that end of the Stone that touched it; yet the same end will attract it, and the other end reject it, and so contrarily. This may easily be experimented upon two Needles touched with one or different Stones, though they have one and the same position; for as you come unto them apply one end of the Magnes near unto them, the North of the one will abhor the North of the other, but the North of the one will always approach to the South of the other: and the same affection is in the Stones themselves. For the finding of the Poles of the Magnes, it may be done by holding a small Needle between your fingers softly, and so moving it from part to part over the Stone, until it be held perpendicular, for that shall be one of the Poles of the Stone which you may mark out; in like manner find out the other Pole. Now to find out which of those Poles is North or South, place a Needle being touched with one of the Poles upon a smooth Convex Body, (as the Nail of ones Finger, or such-like) and mark which way the end of the Needle that was touched turneth: if to the South, then the point that touched it was the South-Pole, &c. and it is most certain, and according to Reason and Experience, that if it be suspended in æquilibrio in the Air, or supported upon the Water, it will turn contrary to the Needle that toucheth it: for then the Pole that was marked for the South shall turn to the North, &c.

PRO-

PROBLEM LXVIII.

Of the Properties of Æolipiles or Bowels to blow the Fire.

THese are concave Vessels of Brasse or Copper or other material, which may indure the Fire; having a small hole very narrow, by which it is filled with Water: then placing it to the fire, before it be hot there is no effect seen; but as soon as the heat doth penetrate it, the Water begins to rarifie, and issueth forth with a hideous and marvelous force; it is pleasure to see how it blows the fire with great noise.



Vitruvius in his first Book of *Architecture*, Cap. 8. approves from these Engines, that Wind is no other thing than a quantity of vapours and exhalations agitated with the air by

rarification and condensation, and we may draw a consequence from it, to shew that a little Water may ingender a very great quantity of Vapours and Air: for a Glass of Water thrown into an *Æolipile* will keep blowing near a whole hour, sending forth his vapours a thousand times greater than it is extended.

Now

Now touching the form of these Vessels, they are not made of one like fashion: Some make them like a Bowl, some like a head painted, representing the Wind, some make them like a Pear: as though one would put it to rost at the fire, when one would have it to blow, for the Tail of it is hollow, in form of a funnel, having at the top a very little hole no greater than the head of a Pin.

Some do accustom to put within the *Æolipile* a crooked Funnel of many foldings, to the end that the Wind that impetuously rolls to and fro within, may imitate the Noise of Thunder. Others content themselves with a simple Funnel placed right upward, somewhat wider at the top than elsewhere, like a Cone, whose Basis is the mouth of the Funnel: and there may be placed a Bowl of Iron or Brass, which by the vapours that are cast out will cause it to leap up, and dance over the Mouth of the *Æolipile*.

Lastly, Some apply near to the hole small Wind-mills, or such-like, which easily turn by reason of the Vapours; or by help of two or more bowed Funnels, a Bowl may be made to turn: these *Æolipiles* are of excellent use for the melting of Metals, and such-like.

Now it is cunning and subtilty to fill one of these *Æolipiles* with Water at so little a hole, and therefore requires the knowledge of a Philosopher to find it out: and the way is thus:

Heat

Heat the *Æolipiles* being empty, and the Air which is within it will become extremely rarified; then being thus hot, throw it into Water, and the Air will begin to be condensed: by which means it will occupy less room: therefore the Water will immediately enter in at the hole to avoid vacuity. Thus you have some Practical Speculation upon the *Æolipile*.

PROBLEM LXIX.

Of the Thermometer: or an Instrument to measure the degrees of Heat and Cold in the Air.

THis Instrument is like a *Cylindrical* Pipe of Glass, which hath a little Ball or Bowl at the top, the small end of which is placed into a Vessel of Water below, as by the Figure may be seen.

Then put some coloured Liquor into the Cylindrical Glass, as blew, red, yellow, green, or such-like: such as is not thick. This being done, the use may be thus.

First, I say, that as the Air inclosed in the *Thermometer* is rarified or condensed, the Water will evidently ascend or descend in the Cylinder: which you may try easily by carrying the *Thermometer* from a place that is hot unto a place that is cold, or without removing of it; if you softly apply the Palm of the Hand upon the Ball of the

Thermo-

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Thermometer: the Glass being so thin, and the Air so capable of Rarification, that at the very instant you may see the Water descend; and your hand being taken a way, it will softly ascend to his former place again. This is yet more sensible when one heats the Ball at the top with his breath, as if one would say a word in his ear, to make the Water to descend by Command, and the reason of this motion is, that the Air heated in the *Thermometer*, doth rarifie and dilate, requiring a greater place; hence presseth the Water, and causeth it to descend: contrariwise when the Air cooleth and condenseth, it occupieth less room; now Nature abhorring vacuity, the Water naturally ascendeth.



In the second place, I say, that by this means one may know the degrees of Heat and Cold which are in the Air each hour of the day; forasmuch as the exterior Air is either hot or cold, the Air which is inclosed in the *Thermometer* doth likewise either rarifie or condense, and therefore the Water ascends or descends; so you shall see that the Water in the morning is mounted high, afterward by little and little it will descend towards noon or mid-day; and towards evening it will again ascend: so in Winter it will mount so high, that all the Cylinder of the *Thermometer* will be full,

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full, but in Summer it will descend so low that scarce there will be perceived in it any water at all.

Those that will determine this change by numbers and degrees, may draw a Line upon the Cylinder of the *Thermometer*; and divide it into 4 degrees, according to the ancient *Philosophers*, or into 4 degrees, according to the *Physicians*, dividing each of these 8 into 8 others, to have in all 64 divisions; and by this way they may not onely distinguish upon what degree the Water ascendeth in the morning, at mid-day, and at any other hour: but also one may know how much one day is hotter or colder than another, by marking how many degrees the Water ascendeth or descendeth, one may compare the hottest and coldest days in a whole year together, with those of another year: Again one may know how much hotter one room is than another, by which also one might keep a Chamber, a Furnace, a Stove, &c. always in an equality of heat, by making the water of the *Thermometer* rest always upon one and the same degree. In brief, one may judge in some measure the burning of Fevers, and near unto what extension the air can be rarified by the greatest heat.

Many make use of these Glasses to judge of the Weather: for it is observed that if the Water fall in 3 or 4 hours a degree, or thereabout, that rain insueth, and the Water will stand at that stay until the Weather change: Mark the Water at your going to bed, for if in the morning it hath descended, rain followeth; but if it be

mounted

mounted higher, it argueth fair weather : so in very cold weather, if it fall suddenly, it is snow, or some sleekey weather that will insue.

PROBLEM LXX.

Of the Proportion of Humane Bodies, of Staines, of Colossus, or huge Images, and of monstrous Giants.

Pythagoras had reason to say, That Man is the measure of all things :

First, Because he is the most perfect amongst all bodily Creatures ; and according to the Maxime of Philosophers, That which is most perfect, and the first in Rank, measureth all the rest.

Secondly, Because in effect the ordinary measure of a foot, the inch, the cubit, the pace, have taken their names and greatness from Humane Bodies.

Thirdly, Because the symmetry and concordancy of the parts is so admirable, that all Works which are well proportionable, as namely the building of Temples, of Ships, of Pillars, and such-like pieces of Architecture, are in some measure fashioned and composed after his Proportion. And we know that the Ark of Noah, built by the Commandment of God, was in length 300 Cubits, in breadth 50 Cubits, in height or depth 30 Cubits, so that the length contains the breadth six times, and ten times the depth : Now a Man being measured,

you will find him to have the same proportion in length, breadth, and depth.

Vilalpandus treating of the Temple of *Solomon* (that Chieftain of Works) was modulated all of good *Architecure*, and curiously to be observed in many pieces to keep the same proportion as the Body to his parts : so that by the greatness of the Work, and proportionable *symmetry*, some dare assure themselves that by knowledge of one onely part of that building, one might know all the measures of that goodly Structure.

Some *Architecists* say that the Foundation of Houses, and Basis of Columns, are as the Foot ; the Top and Roof as the Head, the rest as the Body. Those which have been somewhat more curious, have noted that as in humane Bodies the parts are uniform, as the Nose, the Mouth, &c. these which are double are put on one side or other, with a perfect equality in the same *Architecure*.

In like manner some have been yet far more curious than solid ; comparing all the Ornaments of a Corinth to the parts of the Face, as the Brow, the Eyes, the Nose, the Mouth ; the rounding of Pillars to the writhing of Hair, the Channels of Columns to the Foldings of Womens Robes, &c.

Now building being a Work of the best *Artist*, there is much reason why man ought to make his imitation from the chief Work of Nature, which is man.

Hence it is, that *Vitravius* in his Third Book, and

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and all the best *Architectes* treat of the proportion of man ; amongst others, *Albert Dureus* hath made a whole Book of the measures of Mans Body, from the Foot to the Head ; let them read it who will, they may have a perfect knowledge thereof. But I will content my self, and it may satisfy some, with that which followeth.

First, the length of a man well made, which commonly is called height, is equal to the distance from one end of his finger to the other : when the Arms are extended as wide as they may be.

Secondly, if a man have his Feet and Hands extended or stretched in form of *S. Andrews Cross*, placing one foot of a pair of Compasses upon his Navil, one may describe a Circle which will pass by the ends of his Hands and Feet, and drawing Lines by the terms of the Hands and Feet, you have a Square within a Circle.

Thirdly, the breadth of Man, or the space which is from one side to another ; the Breast, the Head, and the Neck, make the sixth part of all the Body taken in length or height.

Fourthly, the length of the Face is equal to the length of the Hand, taken from the small of the Arm unto the extremity of the longest Finger.

Fifthly, the thickness of the Body taken from the Belly to the Back ; the one or the other is the tenth part of the whole Body, or as some will have it, the ninth part, little less.

Sixthly, the height of the brow, the length of

the Nose, the space between the Nose and the Chin, the length of the Ears, the greatness of the Thumb, are perfectly equal one to the other.

What would you say to make an admirable report of the other parts, if I should reckon them in their least? But in that I desire to be excused, and will rather extract some conclusion upon that which is delivered.

In the first place, knowing the proportion of a Man, it is easie to Painters, Image-makers, &c perfectly to proportionate their work; and by the same is made most evident, that which is related of the Images and Statues of Greece, that upon a day diverse Workmen having enterprised to make the Face of a man, being severed one from another in sundry places, all the parts being made and put together, the Face was found in a most lively and true proportion.

Secondly, It is a thing most clear, that by the help of proportion, the Body of *Hercules* was measured by the knowledge of his Foot only, a Lion by his Claw, the Giant by his Thumb, and a Man by any part of his Body. For so it was, that *Pythagoras* having measured the length of *Hercules* foot, by the steps which were left upon the ground, found out all his height: and so it was that *Phidias* having onely the Claw of a Lion, did figure and draw out all the Beast according to his true type or form, so the exquisite Painter *Timantes*, having painted a *Pygmy* or Dwarf, which he measured with a fadome made with the inch of a Giant, it was sufficient to know the greatness of that Giant.

To

To be short, we may by like method come easily to the knowledge of many fine Antiquities touching Statues, Colossus, and monstrous Giants, onely supposing one had found but one onely part of them, as the Head, the Hand, the Foot, or some Bone mentioned in ancient Histories.

Of Statues, of Colossus, or huge Images.

V *Iruvius* relates in his second Book, that the Architect *Dioscrates* being desirous to put out to the World some notable thing, went to *Alexander* the Great, and proposed unto him a high and special piece of work which he had projected: As to figure out the Mount *Athos* in form of a great Statue, which should hold in his right hand a Town capable to receive ten thousand men; and in his left hand a Vessel to receive all the Water that floweth from the Mountain, which with an Engine should be cast into the Sea. This is a pretty project, said *Alexander*: but because there was not field-room thereabout to nourish and retain the Citizens of that place, *Alexander* was wise not to entertain the Design.

Now let it be required of what greatness this Statue might have been, the Town in his right hand, and the Receiver of Water in his left hand, if it had been made.

For the Statue, it could not be higher than the Mountain it self, and the Mountain was about a mile in height plumb or perpendicular;

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therefore the Hand of this Statue ought to be the 10th part of his height, which would be 500 foot, and so the breadth of his hand would be 250 foot, the length now multiplied by the breadth, makes an hundred twenty five thousand square feet, for the quantity of his hand to make the Town in, to lodge the said 10000 men, allowing to each man near about 12 foot of square ground: Now judge the capacity of the other parts of this *Colossus* by that which is already delivered.

Secondly, *Pliny* in his 34 Book of his Natural History, speaks of the famous *Colossus* that was at *Rhodes*, between whose legs a Ship might pass with his Sails open or displayed, the Statue being of 70 cubits high: and other Histories report that the *Saracens* having broken it, did load 900 Camels with the Metal of it. Now what might be the greatness and weight of this Statue?

For answer, It is usually allowed for a Camels burthen 1200 pound weight; therefore all the *Colossus* did weigh 1080000 pound weight, which is ten hundred and fourscore thousand pound weight.

Now according to the former Rules, the Head being the tenth part of the Body, this Statues Head should be of 7 cubits, that is to say, 10 foot and a half, and seeing that the Nose, the Brow, and the Thumb, are the third part of the Face, his Nose was three foot and a half long, and so much also was his Thumb in length: now the thickness being always the third part of the length,

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length, it should seem that his Thumb was a foot thick at the least.

Thirdly, The said *Pliny* in the same place reports that *Nero* did cause to come out of *France* into *Italy*, a brave and bold Statue-maker called *Zenodocus*, to erect him a *Colossus* of Brass, which was made of 120 foot in height, which *Nero* caused to be painted in the same height. Now would you know the greatness of the Members of this *Colossus*? The breadth would be 20 foot, his Face 12 foot, his Thumb and his Nose 4 foot, according to the proportion before delivered.

Thus I have a fair field or subject to extend myself upon, but it is upon another occasion that it was undertaken. Let us speak therefore a word touching the Giants, and then pass away to the matter.

Of Monstrous GIANTS.

YOU will hardly believe all that which I say touching this, neither will I believe all that which Authors say upon this Subject: notwithstanding you nor I cannot deny but that long ago there have been Men of a most prodigious greatness: for the Holy Writings witness this themselves, in *Deut. iii.* that there was a certain Giant called *Og*, of the Town of *Rabath*, who had a Bed of Iron, the length thereof was 9 cubits, and in breadth 4 cubits.

So in the First of *Kings*, Chap. 17. there is mention made of *Goliath*, whose height was a

palm, and 6 cubits, that is more then 9 foot, he was armed from the Head to the Foot, and his Curiaſs onely, with the Iron of his Lance, weighed five thouſand and fix hundred Shekels, which in our common Weight is more than 233 pound, of 12 ounces to the pound. Now it is certain, that the reſt of his Arms, taking his Target, Helmet, Bracelets, and other Armour together, did weigh at the leaſt five hundred pound, a thing prodigious; ſeeing that the ſtrongeſt man that now is, can hardly bear 200 pound; yet this Giant carries this as a Veſture without pain.

Solinus reporteth in his 5 Chapter of his Hiſtory, that during the *Grecians* War after a great overflowing of the Rivers, there was found upon the Sands the Carcaſe of a man, whoſe length was 33 Cubits, (that is 49 foot and a half) therefore according to the proportion delivered, his Face ſhould be five foot in length, a thing prodigious and monſtrous.

Pliny in his 7 Book and 16 Chap. ſaith, that in the Iſle of *Crete*, or *Candy*, a Mountain being cloven by an Earth-quake, there was a Body ſtanding upright, which had 46 cubits of height. Some believe that it was the body of *Orion* or *Othos*, (but I think rather it was ſome Gholt, or ſome Deluſion) whoſe Hand ſhould have been 7 foot, and his Noſe two foot and a half long.

But that which *Plutarch* in the Life of *Sertorius* reports of, is more ſtrange, who ſaith, That in *Timgy*, a Morative Town, where it is thought that

that the Giant *Antheus* was buried : *Sertorius* not believing that which was reported of his prodigious greatness, caused his Sepulchre to be opened, and found that his Body did contain sixty Cubits in length, then by proportion he should be ten Cubits, or fifteen foot in breadth ; nine foot for the length of his Face, three foot for his Thumb, which is near the capacity of the *Colossus* at *Rhodes*.

But behold here a fine Fable of *Symphoris Campefius*, in his Book intituled *Hortus Gallicus*, who says that in the Kingdom of *Sicily*, at the foot of a Mountain near *Trepane*, in opening the foundation of a House, they found a Cave in which was laid a Giant, which held instead of a Staff a great Post like the Mast of a Ship ; and going to handle it, it moulder'd all into Ashes except the Bones which remained of an exceeding great measure, that in his Head there might be easily placed 5 Quarters of Corn, and by proportion it should seem that his length was 200 cubits, or 300 foot ; if he had said that he had been 300 cubits in length, then he might have made us believe that *Noahs* Ark was but great enough for his Sepulchre.

Who can believe that any man ever had 20 cubits, or 30 foot in length for his Face, and a Nose of ten foot long ? But it is very certain that there have been men of very great stature, as the holy Scriptures before witness, and many Authors worthy of belief relate.

Josephus Acosta in his first Book of the Indian History, Chap. 19. a late Writer, reporteth, that
at

at *Pern* was found the Bones of a Giant which was 3 times greater than these of ours are, that is 18 foot; for there is usually attributed to the tallest ordinary man in these our times but six foot of length; and Histories are full of the description of other Giants of 9, 10, and 12 foot of height, and there hath bin seen in our times some which have had such heights as these.

PROBLEM LXXI.

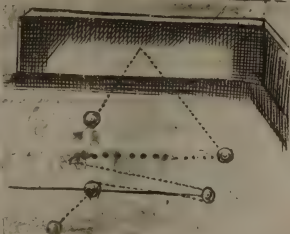
Of the Game at the Palm, at Trap, at Bowles, Pail-mail, and others.

THe Mathematicks often findeth place in sundry Games to aid and assist the Gamesters, though not unknown unto them; hence by Mathematical Principles, the Games at Tennis may be assisted, for all the moving in it is by right Lines and Reflections. From whence comes it, that from the appearances of flat or convex Glasses, the production and reflection of the Species are explained? Is it not by Right Lines? In the same proportion one might sufficiently deliver the motion of a Ball or Bowl by Geometrical Lines and Angles.

But the exercise, experience, and dexterity of the Player seems more in this action than any other Precepts: Notwithstanding I will deliver here some *Maximes*, which being reduced to Practice, and joyned to Experience, will give a great
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exactly observed by local motion, as in the beams of light, and of other qualities, whereof it is necessary to supply it by industry or by strength: otherwise one may be frustrated in that respect.

PROBLEM LXXII.

Of the Game of Square Forms.

Numbers have an admirable secrecy, diversly applied, as before in part is shewed, and here I will say something by way of Transmutation of Numbers.

It is reported that at a certain passage of a square form, there were 4 Gates opposite one to another; that is, one in the middle of each side, and that there were appointed 9 men to defend each front thereof, some at the Gates, and the other at each corner or Angle, so that each Angle served to assist two Faces of the square, if need required: Now this square passage being thus manned to have each side 9, it happened that 4 Souldiers coming by, desired of the Governour of the passage, that they might be entertained into service, who told them he could not admit of more than 9, upon each side of the square: then one of the Souldiers being versed in the Art of Numbers, said, that if he would take them into pay, they would easily place themselves amongst the rest, and yet keep still the order of 9, for each face of the square to defend the Angles

gles and Gates, to which the Governour agreed, and these Souldiers being there some few weeks, liked not their service, but in-
deavoured to remove themselves,

3	3	3	2	5	2	4	1	4
3	A	3	5	B	5	1	C	1
3	3	3	2	5	2	4	1	4
0	3	0	1	2	1	2	1	2
3	O	3	2	G	2	1	H	1
0	3	0	1	2	1	2	1	2

and so laboured with some of the rest, that each of these four Souldiers took away his Comrade with him, and so departed; yet left to defend each side of the passage, and how may this be?

It's answered thus: In the first form the men were as the figure *A*, then each of these 4 Souldiers placed themselves at each Gate, and removing one man from each Angle to each Gate, then would they be also 9 in each side, according to the figure *B*. Lastly, these 4 Souldiers at the Gates take away each one his Comrade, and placing 2 of these men which are at each Gate to each Angle, there will be still 9 for each side of the square, according to the figure *C*. In like manner if there were 12 men, how might they be placed about a Square that the first side shall have 3 every way, then disordered, so that they might be 4 every way; and lastly, being transposed might make 5 every way? And this is according to the Figures *F, G, H*.

PRO-

PROBLEM LXXIII.

*How to make the String of a Viol sensibly shake,
without any one touching it ?*

THis is a Miracle in Musick, yet easie to be experimented. Take a Viol, or other Instrument, and choose two Strings, so that there be one between them; make these two Strings agree in one and the same tune: then move the Viol-bowe upon the greater String, and you shall see a wonder: for in the same time that that shakes which you play upon, the other will likewise sensibly shake without any one touching it; and it is more admirable that the String which is between them will not shake at all: and if you put the first String to another tune or note, and loosing the pin of the String, or stopping it with your finger in any fret, the other String will not shake: and the same will happen if you take two Viols, and strike upon a string of the one, the string of the other will sensibly shake.

Now it may be demanded, how comes this shaking? Is it in the occult sympathy, or is it in the strings being wound up to like notes or tunes, that so easily the other may receive the impression of the Air, which is agitated or moved by the shaking or the trembling of the other? And whence is it that the Viol-bowe moved upon the first string, doth instantly in the same time move the third string, and not the second, if the cause

be

be not either in the first or second? I leave to others to descant on.

Examination.

IN this Examination we have something else to imagine than the bare sympathy of the Cords one to another: for first there ought to be considered the different effect that it produceth by extention upon one and the same Cord in capacity: then what might be produced upon different Cords of length and bigness to make them accord in a Unisone or Octavo, or some Consort intermediate: this being naturally examined, it will be facil to lay open a way to the knowledge of the true and immediate cause of this noble and admirable Phœnomeny. Now this will sensibly appear when the Cords are of equal length and greatness, and set to an Unisone; but when the Cords differ from their equality, it will be less sensible: hence in one and the same Instrument, Cords at a Unisone shall excite or shake more than that which is at an Octavo, and more than those which are of an intermediate proportional Consort: as for the other Consorts they are not exempted, though the effect be not so sensible, yet more in one than in another: and the Experiment will seem more admirable in taking two Lutes, Viols, &c. and in setting them to one tune: for then in touching the Cord of the one, it will give a sensible motion to the Cord of the other: and not only so, but also a Harmony.

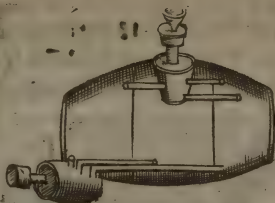
PROBLEM LXXIV.

Of a Vessel which contains three several kinds of Liquor, all put in at one Bung-hole, and drawn out at one Tap severally without mixture.

THe Vessel is thus made, it must be divided into three Cells, for to contain the three Liquors, which admit to be Sack, Claret, and White-wine: Now in the Bung-hole there is an Engine with three Pipes, each extending to his proper Cell, into which there is put a Broach or Funnel pierced in three places, in such sort, that placing one of the holes right against the pipe which answereth unto him, the other two pipes are stopped; then when it is full, turn the Funnel, and then the former hole will be stopped, and another open, to cast in other Wine without mixing it with the other.

Now to draw out also without mixture, at the bottom of the Vessel there must be placed a Pipe or Broach, which may have three Pipes; and a Cock pierced with three holes so artificially done, that turning the Cock, the hole which answereth to such of the Pipes that is placed at the bottom may issue forth such Wine as belongeth to that Pipe, and turning the Cock to another Pipe, the former hole will be stopp'd; and

so there will issue forth another kind of Wine without any mixtures ; but the Cock may be so ordered that there may come out by it two Wines together , or all three kinds at once : but it seems



best when that in one Vessel and at one Cock, a man may draw several kinds of Wine, and which he pleaseth to drink.

PROBLEM LXXV.

Of Burning-Glasses.

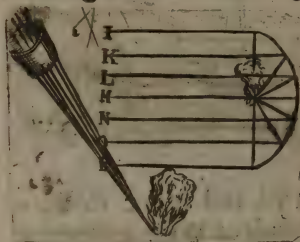
IN this ensuing Discourse I will shew the invention of *Prometheus*, how to steal fire from Heaven, and bring it down to the Earth ; this is done by a little round Glass, or made of Steel, by which one may light a Candle, and make it flame, kindle Fire-brands to make them burn, melt Lead, Tin, Gold, and Silver, in a little time : With as great ease as though it had been put into a Cruzet over a great fire.

Have you not read of *Archimedes* of *Syracusa*, who when he could not come to the Ships of *Marcellus* which besieged that place, to hinder and impeach their approach, he flung huge stones by his Engines to sink them into the Sea,

K

and

and transformed himself into *Jupiter*, thundering down from the highest Towers of the Town, his Thunder-bolts of Lightning into the Ships, causing a terrible burning, in despite of *Neptune*



and his Watry Region: *Zonaras* witnesseth that *Proclus* a brave Mathematician, burned in the same manner the Ships of *Vitalian*, which were come to besiege *Constantinople*,

and daily experience may let you see great effects of burning: for a Bowl of Crystal polished, or a Glass thicker in the middle than at the edges, will burn exceedingly; nay a Bottle full of Water exposed to the Sun, will burn when the Sun shineth hot; and children use with a Glass to burn Flies which are against the Walls, and their fellows Cloaths.

But this is nothing to the burning of those Glasses which are hollow, namely those which are of Steel well polished, according to a parabolical or oval section. A spherical Glass, or that which is according to the segment of a *Sphere*, burns very effectually about the fourth part of the Diameter; notwithstanding the Parabolic and Ecliptick sections have a great effect: by which Glasses there are also divers Figures represented forth to the Eye.

The cause of this burning is the uniting of the beams of the Sun, which heat mightily in the point

point of concurrence or inflammation, which is either by Transmission or Reflection : Now it is pleasant to behold when one breatheth in the point of concurrence, or throweth small dust there, or sprinkles vapours of hot Water in that place, by which the Pyramidal point, or point of inflammation is known. Now some Authors promise to make Glasses which shall burn a great distance off, but yet not seen vulgarly produced, of which if they were made, the Parabolie makes the greatest effect, and is generally held to be the invention of *Archimedes* or *Proclus*.

Maginus in the 5 Chap. of his Treatise of Spherical Glasses, shews how one may serve himself with a concave Glass, to light fire in the shadow, or near such a place where the Sun shines not, which is by help of a flat Glass, by which may be made a percussion of the beams of the Sun into the concave Glass, adding unto it that it serves to good use to put fire to a Mine, provided that the combustible matter be well applied before the concave Glass; in which he says true: but because all the effect of the practice depends upon the placing of the Glass and the Powder which he speaks not of: I will deliver here a Rule more general.

How one may place a Burning-glass with his combustible matter, in such sort, that at a convenient hour of the day, the Sun shining, it shall take fire & burn.

IT is certain that the point of inflammation or burning, is changed as the Sun changeth place, and no more nor less than the shadow turns

about the Style of a Dial; therefore have regard to the Suns motion and his height and place: a Bowl of Cryſtal in the ſame place that the top of the Style is, and the Powder or other combuſtible matter under the Meridian, or hour of 12, 1, 2, 3, &c. or any other hour, and under the Suns Arch for that day: Now the Sun coming to the hour of 12; to 1, 2, 3, &c. the Sun caſting his Beams through the Cryſtal Bowl, will fire the material or combuſtible thing, which meets in the point of burning: The like may be obſerved of other Burning-glaſſes.

Examination.

IT is certain in the firſt part of this Problem, that Conical, Concave, and Spherical Glaſſes, of what matter ſoever, being placed to receive the beams of the Sun, will excite heat, and that heat is ſo much the greater, by how much it is near the point of con-
course or inflammation. But that Archimedes or Proclus did fire or burn Ships with ſuch Glaſſes, the ancient Hiſtories are ſilent, yea themſelves ſay nothing: beſides the great difficulty that doth oppoſe it in remoteneſs, and the matter that the effect is to work upon. Now by a common Glaſs we fire things near at hand, from which it ſeems very facil to ſuch which are leſs read, to do it at a far greater diſtance, and ſo by relation ſome deliver to the World by ſuppoſition that which was never done in action: this we ſay the
rather,

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rather, not to take away the most excellent and admirable effects which are in Burning-glasses, but to shew the variety of Antiquity, and truth of History: and as touching to burn at a great distance, as is said of some, it is absolutely impossible; and that the Parabolical and Oval Glasses were of Archimedes and Proclus invention is much uncertain; for besides the construction of such Glasses, they are more difficult than the obtuse concave ones are; and further, they cast not a great heat but near at hand; for if it be cast far off, the effect is little, and the heat weak, or otherwise such Glasses must be greatly extended to contract many beams to amass a sufficient quantity of Beams in Parabolical and Conical Glasses, the point of inflammation ought to concur in a point, which is very difficult to be done in a due proportion. Moreover if the place be far remote, as is supposed before, such a Glass cannot be used but at a great inclination of the Sun, by which the effect of burning is diminished by reason of the weakness of the Sun-beams.

And here may be noted in the last part of this Problem, that by reason of obstacles if one plain Glass, be not sufficient, a second Glass may be applied to help it: that so if by one simple reflection it cannot be done, yet by a double reflection the Sun-beams may be cast into the said Cavern or Mine, and though the reflected Beams in this case be weak, yet upon a fit combustible matter it will not fail to do the effect.

PROBLEM LXXVI.

Containing many pleasant Questions by way of Arithmetick.

I Will not insert in this Problem that which is drawn from the Greek Epigrams; but proposing the Question, immediately will give the Answer also, without staying to shew the manner how they are answered; In this I will not be tied to the Greek Terms, which I account not proper for this place, neither to my purpose. Let those that will read *Diophanta Sebeubelius* upon *Euclide* and others, and they may be satisfied.

Of the As and the Mule.

IT happened that the Mule and the As upon a day making a Voyage, each of them carried a Barrel full of Wine: now the lazy As feeling her self over-loaden, complained and bowed under her burthen; which the Mule seeing, said unto her, being angry, (for it was in the time when Beasts spake) Thou great As, wherefore complaineest thou? If I had but onely one measure of that which thou carriest, I should be loaden twice as much as thou art; and if I should give a measure of my loading to thee, yet my burthen would beas much as thine,

Now

Now how many measures did each of them carry? Answer: The Mule did carry 7 measures, and the Ass 5 measures: For if the Mule had one of the measures of the Asses loading, then the Mule would have 8 measures, which is double to 4, and giving one to the Ass, each of them would have equal burthens: to wit, 6 measures apiece.

Of the Number of Souldiers that fought before Old Troy.

Homer being asked by Hesiodus how many Grecian Souldiers came against Troy? Answered him thus: The Grecians, said Homer, made 7 Fires, or had 7 Kitchens, and before every Fire, or in every Kitchen there were 50 Broaches turning to roast a great quantity of Flesh, and each Broach had Meat enough to satisfy 900 men: Now judge how many men there might be. Answer: 315000; that is, three hundred and fifteen thousand men: which is clear by multiplying 7 by 50, and the product by 900 makes the said 315000.

Of the Number of Crowns that two Men had.

John and Peter had a certain number of crowns: John said to Peter, If you give me 10 of your crowns, I shall have three times as much as you have: but Peter said to John, If you give me 10 of your crowns, I shall have 5 times as much as you have: How much had each of them? Answer,

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swer, *John* had 15 crowns and $\frac{5}{7}$ sevenths of a crown, and *Peter* had 18 crowns and $\frac{4}{7}$ sevenths of a crown. For if you add 10 of *Peters* crowns to those of *Johns*, then should *John* have 25 crowns and $\frac{5}{7}$ sevenths of a crown, which is triple to that of *Peters*, viz. 8, and $\frac{4}{7}$ sevenths; and *John* giving 10 to *Peter*, *Peter* should have then 28 crowns, and $\frac{4}{7}$ sevenths of a crown, which is *Quintupla*, or 5 times as much as *John* had left, viz. 5 crowns and $\frac{5}{7}$ sevenths.

In like manner two Gamesters playing together, *A* and *B*, after play *A* said to *B*, Give me 2 crowns of thy money, and I shall have twice as much as thou hast: and *B* said to *A*, Give me 2 crowns of thy money, and I shall have 4 times as much as thou hast: now how much had each? Answer, *A* had 3 and $\frac{5}{7}$ sevenths, and *B* had 4 and $\frac{6}{7}$ sevenths.

About the hour of the day.

Some one asked a Mathematician what a clock it was; who answered that the rest of the day is four thirds of that which is past: Now judge what a clock it is. Answer: If the day were according to the Jews and ancient Romans, which made it always to be 12 hours, it was then the 5 hour, and one seventh of an hour, so there remained of the whole day $\frac{6}{7}$, that is, 6 hours, and $\frac{6}{7}$ sevenths of an hour. Now if you take the $\frac{1}{7}$ of $\frac{6}{7}$, it is $\frac{1}{7^2}$, or 1 and $\frac{5}{7}$, which multiplied by 4 makes 6 and $\frac{6}{7}$, which is the remainder of the day, as before: but if the day had been 24 hours, then the hour had been ten of the clock and

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and two sevenths of an hour, which is found out by dividing 12, or 24 by .

There might have been added many curious Propositions in this kind, but they would be too difficult for the most part of People : therefore I have omitted them.

Of Pythagoras his Scholars.

Pythagoras being asked what number of Scholars he had, answered that half of them studied *Mathematicks*, the fourth part *Physick*, the seventh part *Rhetorick*, and beside he had 3 Women : Now judge you, saith he, how many Scholars I have. Answer : He had in all 28, the half of which is 14, the quarter of which is 7, and the seventh part of which is 4, which 14, 7, and 4, makes 25, and the other 3 to make up the 28, were the 3 Women.

Of the Number of Apples given amongst the Graces and the Muses.

THe Three Graces carrying Apples upon a day, the one as many as the other, met with the Nine Muses, who asked of them some of their Apples ; so each of the Graces gave to each of the Muses alike, and the Distribution being made, they found that the Graces and the Muses had one as many as the other : The question is, How many Apples each Grace had, and how

how many they gave to each Muse? To answer the question, joyn the number of Graces and Muses together, which makes 12, and so many Apples had each Grace: Now may you take the double, tripple, &c. of 12, that is 24, 36, &c. conditionally, that if each Grace had but 12, then may there be allotted to each Muse but one only; if 24, then to each 2 Apples, if 26, then to each Muse 3 Apples, and so the distribution being made, they have a like number, that is, one as many as the other.

Of the Testament or last Will of a dying Father.

A Dying Father left a thousand Crowns among his two Children, the one being legitimate, and the other a Bastard; conditionally, that the fifth part which his legitimate Son should have, should exceed by 10 the fourth part of that which the Bastard should have: What was each ones part? Answer: The legitimate Son had 577 crowns, and $\frac{7}{2}$, and the Bastard 422 crowns and $\frac{2}{5}$, now the fifth part of 577 and $\frac{7}{2}$ ninths is 115, and $\frac{5}{2}$, and the fourth part of 422 and $\frac{2}{5}$ is 105 and $\frac{5}{2}$, which is less than 115 $\frac{5}{2}$ by 10, according to the will of the Testator.

Of the Cups of Cræsus.

Cræsus gave to the Temple of the Gods six Cups of Gold, which weighed together 600 Drams, but each Cup was heavier one than another by one Dram: How much did each of them

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them therefore weigh? Answer: The first weighed 102 Drams and a half, the second 101 Drams and a half, the third 100 Drams and a half, the fourth 99 and a half, the fifth 98 and a half, and the sixth Cup weighed 97 Drams and a half; which together make 600 Drams, as before.

Of Cupid's Apples.

Cupid complained to his Mother that the Muses had taken away his Apples; *Clio*, said he, took from me the fifth part, *Euterpe* the twelfth part, *Thalia* the eighth part, *Melpomene* the twentieth part, *Erates* the seventh part, *Terpsimenes* the fourth part, *Polyhymnia* took away 30, *Urania* 120, and *Caliope* 300; so there were left me but 5 Apples: How many had he in all at the first? I answer 3360.

There are an infinite of such-like Questions amongst the Greek Epigrams: but it would be unpleasant to express them all: I will onely add one more, and shew a general Rule for all the rest.

Of a Mans Age.

A Man was said to pass the sixth part of his Life in Childhood, the fourth part in his Youth, the third part in Manhood, and 18 years beside in old Age: What might his Age be? The Answer is, 72 years: which, and all others, is thus resolved: multiply $\frac{1}{6}$ and $\frac{1}{3}$ together, that is, 6 by 4 makes 24, and that again by 3 makes

72,

72, then take the third part of 72, which is 24, the fourth part of it, which is 18, and the sixth part of it, which is 12, these added together make 54, which taken from 72 rests 18, this divided by 18, (spoken in the Question) gives 1, which multiplied by the sum of the parts, viz. 72, makes 72, the Answer as before.

Of the Lion of Bronze placed upon a Fountain with this Epigram :

Out of my right Eye if I let Water pass, I can fill the Cistern in 2 days : if I let it pass out of the left Eye, it will be filled in 3 days : if it pass out of my feet, the Cistern will be 4 days a filling ; but if I let the Water pass out of my mouth, I can fill the Cistern then in 6 hours : in what time should I fill it, if I pour forth the Water at all the passages at once ?

The Greeks (the greatest talkers in the world) variously apply this Question to divers Statues and Pipes of Fountains : and the Solution is by the Rule of Three, by a general Rule, or by *Algebra*. They have also in their *Anthology* many other Questions, but because they are more proper to exercise than to recreate the Spirit, I pass them over (as before with silence.

PROBLEM LXXVII.

Divers Excellent and Admirable Experiments upon Glasses.

There is nothing in the world so beautiful as Light: and nothing more recreative to the sight, than Glasses which reflect: therefore I will now produce some Experiments upon them, not that I will dive into their depth (that were to lay open a mysterious thing) but that which may delight and recreate the Spirits: Let us suppose therefore these Principles, upon which is built the demonstration of the apparances which are made in all sorts of Glasses.

First, That the Rays or Beams which reflect upon a Glas, make the Angle of Incidence equal to the Angle of Reflection, by the first Theo. of the *Catoptick* of *Enc.*

Secondly, That in all plain Glasses, the Images are seen in the perpendicular Line to the Glas, as far within the Glas as the Object is without it.

Thirdly, In concave or convex Glasses, the Images are seen in the right line which passeth from the Object, and through the Centre in the Glas. Theo. 17. and 18.

And here you are to understand, that there is not meant onely those which are simple Glasses, or Glasses of Steel, but all other Bodies, which may represent the visible Image of things, by reason

reason of their reflection, as Water, Marble, Metal, or such like. Now take a Glass in your hand, and make Experiment upon that which followeth.

Experiments upon flat and plain Glasses.

First, A man cannot see any thing in these Glasses, if he be not directly and in a perpendicular line before it, neither can he see an Object in these Glasses, if it be not in such a place that makes the Angle of Incidence equal to the Angle of Reflection: therefore when a Glass stands upright, that is, perpendicular to the Horizon, you cannot see that which is above, except the Glass be placed down flat: and to see that on the right hand, you must be on the left hand, &c.

Secondly, An Image cannot be seen in a Glass, if it be not raised above the surface of it; or place a Glass upon a Wall, you shall see nothing which is upon the plain of the Wall; and place it upon a Table or Horizontal Plain, you shall see nothing of that which is upon the Table.

Thirdly, In a plain Glass all that is seen appears or seems to sink behind the Glass, as much as the Image is before the Glass, as before is said.

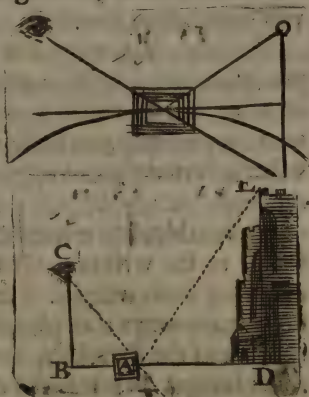
Fourthly, (As in Water) a Glass lying down flat or Horizontal, Towers, Trees, Men, or any height doth appear inverfed or upside-down; and a Glass placed upright, the right hand of the Image seems to be the left, and the left seems to be the right.

Fifthly,

Fifthly, Will you see in a Chamber that which is done in the Street, without being seen? Then a Glas must be so disposed, that the Line upon which the Images come on the Glas, make the Angle of Incidence equal to that Angle of Reflection.

Sixthly, An height, (as suppose DE) may be measured by a plain Glas, as let the Glas be G , placed down upon the ground, and let the Eye be at C , so far removed from the Glas,

that the Eye at C , may see the top of the Tower E in the Angle or edge of the Glas at A , but in the line of reflection CA , then measure the distance between your foot B , and the point A , and also the distance between the Glas A , and the foot



of the Tower D , viz. AD . Now as often as AB is found in AD , so often doth the height of the Tower ED contain the distance from your Eye to the foot, viz. CB , for the Triangles A, B, C , and A, D, E , are equal Triangles: therefore as BA to AD , so CB , to ED , or alternately as BA to EC , so AD to DE .

Sevently, Present a Candle upon a plain Glas, and look flaunting upon it, so that the Candle and the Glas be near in a right Line, you shall

shall see 3, 4, 5, &c. Images, from one and the same Candle

Eighthly, Take two plain Glasses, and hold them one against the other, you shall alternately see them oftentimes one within the other, yea within themselves, again and again.

Ninthly, If you hold a plain Glas behind your head, and another before your face, you may see the hinder part of your head, in that Glas which you hold before your face.

Tenthly, You may have a fine Experiment if you place two Glasses together, that they make an acute Angle, and so the lesser the Angle is, the more apparances you shall see, the one direct, the other inversed, the one approaching, and the other retiring.

Eleventhly, It is a wonder and astonishment to some, to see within a Glas an Image, without knowing from whence it came, and it may be done many ways: as place a Glas higher than the Eye of the Beholder, and right against it is some Image; so it resteth not upon the Beholder, but doth cast the Image upwards. Then place another object, so that it reflect, or cast the Image downward to the Eye of the Spectator, without perceiving it being hid behind something, for then the Glas will represent a quite contrary thing, either that which is before the Glas, or that which is about it, to wit, the other hidden object.

Twelfthly, If there be ingrav'd behind the back-side of a Glas, or drawn any Image upon it, it will appear before as an Image, without any appearance or portraicture to be perceived.

Exampl-

Examination.

THis Twelfth Article of engraving an Image behind the Glass, will be of no great consequence; because the lineaments will seem so obscure; but if there were painted some Image, and then that covered according to the usual covering of Glasses behind, and so made up like an ordinary Looking-Glass, having an Image in the middle, in this respect it would be sufficiently pleasant: and that which would admire the ignorant, and able to exercise the most subtillest, and that principally if the Glass be in an obscure place, and the Light which is given to it be somewhat far off.

THirteenthly, Place a Glass near the floor of a Chamber, and make a hole through the place under the Glass, so that those which are below may not perceive it, and dispose a bright Image under the hole, so that it may cast his species upon the Glass, and it will cause admiration to those which are below that know not the cause. The same may be done by placing the Image in a Chamber adjoyning, and so make it to be seen upon the side of a Wall.

Fourteenthly, In these Channel-Images which shew one side a Deaths Head, and another side a fair Face, and right before some other thing; it is a thing evident, that setting a plain Glass

L side=

sidewise to this Image, you shall see it in a contrary thing, than that which was presented before sidewise.

Fifteenthly, Lastly, It is a fine secret to present unto a plain Glass Writing with such industry, that one may read it in the Glass, and yet out of the Glass there is nothing to be known, which will thus happen, if the Writing be writ backward: but that which is more strange, to shew a kind of Writing to a plain Glass, it shall appear another kind of Writing both against sense and form; as if there were presented to the Glass WEL, it would shew it MET; if it were written thus, MIV, and presented to the Glass, it would appear thus VIM; for in the first, if the Glass lie flat, then the things are inversed that are perpendicular to the Glass; if the Glass and the Object be upright, then that on the right hand is turned to the left, as in the latter.

And here I cease to speak further of these plain Glasses, either of the admirable multiplications, or appearances, which is made in a great number of them; for to content the sight in this particular, one must have recourse to the Cabinets of Great Personages who enrich themselves with most beautiful ones.

Experiments upon Gibbous or Convex Spherical Glasses.

IF they be in the form of a Bowl, or part of a great Globe of Glass, there is singular contentment to contemplate on them.

First

First, Because they present the Objects less and more gracious, and by how much more the Images are separated from the Glass, by so much the more they diminish in magnitude.

Secondly, They that shew the Images plaiting, or folding, which is very pleasant, especially when the Glass is placed down, and behold in it some blanching, seeling, &c. The upper part of a Gallery, the porch of a Hall, &c. for they will be represented as a great Vessel having more belly in the middle than at the two ends, and Posts and Joists of Timber will seem as Circles.

Thirdly, That which ravisheth the Spirits by the Eye, and which shames the best Perspective Painting that a Painter can make, is the beautiful contraction of the Images, that appear within the sphericity of these small Glasses: for present the Glass to the lower end of a Gallery, or at the Corner of a great Court full of People, or towards a great Street, Church, Fortification, an Army of Men, to a whole City; all the fair Architecture and appearances will be seen contracted within the circuit of the Glass with such variety of Colours, and distinctions in the lesser parts, that I know not in the world what is more agreeable to the sight, and pleasant to behold, in which you will not have an exact proportion, but it will be variable, according to the distance of the Object from the Glass.

Experiments upon hollow or concave spherical Glasses.

I Have heretofore spoken how they may burn, being made of Glass or Metal, it remains now that I deliver some pleasant Uses of them, which they represent unto our sight; and so much the more notable it will be, by how much the greater the Glass is, and the Globe from whence it is extracted: for it must in proportion as a segment of some be made Circle or Orb.

Examination.

IN this we may observe that a Section of two, three, or four Inches in Diameter, may be segments of Spheres, of two, three, or four foot; nay of so many fadom, for it is certain that amongst those which comprehend a great portion of a lesser Sphere, and those which comprehend a little segment of a great Sphere, whether they be equal or not in section, there will happen an evident difference in one and the same Experiment, in the number, situation, quantity and figure of the Images of one or many different objects, and in burning there is a great difference.

MAginus, in a little Tractate that he had upon these Glasses, witnesseth of himself that he had caused many to be polished for sundry

Mathematical Recreation. 149

dry great Lords of Italy and Germany, which were segments of Globes of two, three, and four foot diameter; and I wish you had some such-like to see the experiments of that which followeth; it is not difficult to have such made, or bought here in Town, the contentment herein would bear with the cost.

Examination.

Touching Maginus he hath nothing aided us to the knowledge of the truth by his Extract out of Vitellius, but left it; expecting it from others, rather than to be plunged in the search of it himself affecting rather the forging of the matter, and composition of the Glasses, than Geometrically to establish their Effects.

First therefore in concave Glasses, the Images are sometimes seen upon the surface of the Glasses, sometimes as though they were within it and behind it, deeply sunk into it, sometimes they are seen before, and without the Glass, sometimes between the Object and the Glass; sometimes in the place of the Eye, sometimes farther from the Glass than the Object is: which comes to pass by reason of the divers concurrence of the beams, and change of the place of the Images in the line of reflection.

Examination.

THe relation of these appearances pass current amongst most men, but because the Curious may not receive prejudice in their Experiments, something ought to be said thereof, to give it a more lively touch: in the true causes of these appearances, in the first place it is impossible that the Image can be upon the surface of the Glas, and it is a principal point to declare truly in which place the Image is seen in the Glas: those that are more learned in Optical knowledge affirm the contrary, and Nature it self gives it a certain place according to its position, being always seen in the line of Reflection which Alhazen, Vitellius, and others full of great knowledge, have confirmed by their Writings: but in their particular they were too much occupied by the Authority of the Ancients, who were not sufficiently circumspect in experience, upon which the principles of this subject ought to be built, and searched not fully into the true cause of these appearances, seeing they leave unto Posterities many falsities in their Writings, as those that followed them for the most part fell into the like errors.

As for the Images to hide in the Eye, it cannot be, but is impertinent and absurd; but it followeth that by how much nearer the Object approacheth to the Glas, by so much the more the appearances seem to come to the Eye: and if the Eye be without the point of concurrence, and the Object also; as long as the Object

ject approacheth thereto, the representation of the Image cometh near the Eye, but passing the point of concurrence, it goes back again: These appearances thus approaching, do not a little astonish those who are ignorant of the cause: they are inversed, if the Eye be without the point of concurrence until the Object be within, but contrarily if the Eye be between the point of concurrence and the Glass, then the Images are direct: and if the Eye or the Object be in the point of concurrence, the Glass will be enlightened, and the Images confused, and if there were but a spark of fire in the said point of concurrence, all the Glass would seem a burning fire-brand, and we dare say it would occur without chance, and in the night be the most certain and subtlest light that can be, if a candle were placed there. And whosoever shall enter into the search of the truth of new Experiments in this subject, without doubt he will confirm what we here speak of, and will find new Lights with a convenient position to the Glass, he will have reflection of quantities of Truth, and fine Secrets in Nature, yet not known, which he may easily comprehend if he have but an indifferent sight, and may assure himself that the Images cannot exceed the sight, nor trouble it, a thing too much absurd to Nature.

And it is an absolute verity in this Science, that the Eye being once placed in the line of Reflection of any Object, and moved in the same line: the Object is seen in one and the same place immutable; or if the Image and the Eye move in their own lines, the representation in the Glass seems to invest it self continually with a different figure.

NOW the Image coming thus to the Eye, those which know not the secret, draw their Sword when they see an Image thus to issue out of the Glass, or a Pistol which some one holds behind: and some Glasses will shew a Sword wholly drawn out, separated from the Glass, as though it were in the Air: and it is daily exercised, that a man may touch the Image of his hand or his face out of the Glass, which comes out the farther, by how much the Glass is great, and the Centre remote,

Examination.

NOW that a Pistol being presented to a Glass behind a man, should come out of the Glass, and make him afraid that stands before, seeming to shoot at him, this cannot be: for no Object whatsoever presented to a concave Glass, if it be not nearer to the Glass than the Eye is, it comes not out to the sight of the party; therefore he needs not fear that which is said to be behind his back, and comes out of the Glass; for if it doth come out, it must then necessarily be before his face, so in a concave Glass whose Centre is far remote, if a Sword, Stick, or such-like, be presented to the Glass, it shall totally seem to come forth of the Glass, and all the hand that holds it. And here generally note, that if an Image be seen to issue out of the Glass to come towards the face of any one that

that stands by, the Object shall be likewise seen to thrust towards that face in the Glass, and may easily be known to all the standers by: so, many persons standing before a Glass, if one of the company take a Sword, and would make it issue forth towards any other that stands there, let him chuse his Image in the Glass, and carry the Sword right towards it, and the effect will follow. In like manner ones hand being presented to the Glass as it is thrust towards the Centre, so the representation of it comes towards it, and so the hands will seem to be united, or to touch one another.

FROM which may be concluded, if such a Glass be placed at the ceiling or planching of a Hall, so that the face be Horizontal, and look downward; one may see under it as it were a man hanging by the feet, and if there were many placed so, one could not enter into that place without great fear or scaring: for one should see many men in the Air as if they were hanging by the feet.

Examination.

Touching a Glass tied at a Ceiling or Planching, that one may see a man hang by the Feet in the Air, and so many Glasses, so many Men may be seen: without caution this is very absurd, for if the Glass or Glasses be not so great that the Centre of the Sphere upon which it was made, extend not near to the Head of him that is under it, it will

will not pleasantly appear; and though the Glasse should be of that capacity that the Centre did extend so far, yet will not the Images be seen to them which are from the Glasse, but onely to those which are under it or near unto it: and to them it will notably appear. And it would be most admirable to have a Gallery vaulted over with such Glasses, which would wonderfully astonish any one that enters into it: for all the things in the Gallery would be seen to hang in the Air, and you could not walk without encountering Airy Apparitions.

Secondly, In flat or plain Glasses the Image is seen equal to his Object, and to represent a whole man, there ought to be a Glasse as great as the Image is: In convex Glasses the Images are seen always less, in concave Glasses they may be seen greater or lesser, but not truly proportionable, by reason of the divers reflections which contracts or enlargeth the Species: when the eye is between the Centre and the surface of the Glasse, the Image appears sometimes very great and deformed; and those which have but the appearance of the beginning of a Beard on their Chin, may chear up themselves to see they have a great Beard; those that seem to be fair, will thrust away the Glasse with despight, because it will transform their beauty: those that put their hand to the Glasse, will seem to have the hand of a Giant, and if one puts his finger to the Glasse, it will be seen as a great Pyramide of Flesh, inversed against his finger.

Thirdly,

Thirdly, It is a thing admirable that the Eye being approached to the point of concourse of the Glafs, there will be seen nothing but an intermixture or confufion: but retiring back a little from that point (because the Rays do there meet) he shall fee his Image inverfed, having his Head below, and his Feet above.

Fourthly, The divers appearances caused by the motion of Objects, either retiring or approaching: whether they turn to the right hand or to the left hand, whether the Glafs be hung against a Wall, or whether it be placed upon a Pavement, as also what may be represented by the mutual aspect of Concave Glasses, with plain and Convex Glasses: but I will with silence pass them over, only say something of two rare Experiments more as followeth.

The first is to represent by help of the Sun such letters as one would upon the front of a house, so that one may read them: *Maginus* doth deliver the way thus: Write the Letters, saith he, sufficiently big, but inverfed upon the surface of the Glafs, with some kind of colour, or these Letters may be written with Wax, (the easier to be taken out again) for then placing the Glafs to the Sun, the Letters which are written there will be reverberated or reflected upon the Wall: hence it was perhaps that *Pythagoras* did promise with this invention to write upon the Moon.

In the second place, how a man may sundry ways help himself with such a Glafs, with a lighted Torch or Candle, placed in the point of concourse or inflammation, which is near the fourth
part

part of the Diameter : for by this means the light of the Candle will be reverberated into the Glass, and will be cast back again very far by parallel lines, making so great a light that one may clearly see that which is done far off, yea in the camp of an Enemy ; and those which shall see the Glass afar off, will think they see a Silver Basin inlightened, or a fire more resplendent then the Torch. It is this way that there are made certain Lanthorns which dazel the Eyes of those which come against them ; yet it serves singular well to enlighten those which carry them, accommodating a Candle with a little hollow Glass, so that it may successively be applied to the point of inflammation.

In like manner by this reflected Light one may read far off, provided that the Letters be indifferent great, as an Epitaph placed high, or in a place obscure ; or the Letter of a Friend which dares not approach without peril or suspicion.

Examination.

THis will be scarce sensible upon a Wall remote from the Glass, and but indifferently seen upon a Wall which is near the Glass, and withal it must be in obscurity or shadowed, or else it will not be seen. To cast Light in the night to a place remote, with a Candle placed in the point of concourse or inflammation, is one of the most notablest properties which can be

be shewn in a concave Glass: for if in the point of inflammation of a Parabolical Section, a Candle be placed, the Light will be reflected by Parallel Lines, as a Column or Cylinder; but in the Spherical Section it is defective in part, the beams being not united in one point, but somewhat scattering: notwithstanding it casteth a very great beautiful Light.

LASTLY, Those which fear to hurt their sight by the approach of Lamps or Candles, may by this artifice place at some corner of a Chamber a Lamp with a hollow Glass behind it, which will commodiously reflect the Light upon a Table, or to a place assigned: so that the Glass be somewhat raised to make the Light to streck upon the Table with sharp Angles, as the Sun doth when it is but a little elevated above the Horizon, for this Light shall exceed the Light of many Candles placed in the Room, and be more pleasant to the sight of him that useth it.

Of other Glasses of Pleasure.

FIRST, The Columnary and Pyramidal Glasses that are contained under right lines, do represent the Images as plain Glasses do, and if they be bowing, then they represent the Image as the concave and convex Glasses do.

Secondly, Those Glasses which are plain, but have ascents of Angles in the middle, will shew one to have four Eyes, two Mouths, two Noses, &c.

Exami-

Examination.

THese Experiments will be found different, according to the diverse meeting of the Glasses, which commonly are made scuing-wise at the end, by which there will be two divers superficies in the Glass, making the exterior Angle somewhat raised, at the interior onely one superficies, which may be covered according to ordinary Glasses to cause a reflection, and so it will be but one Glass, which by refraction according to the different thickness of the Glass, and different Angles of the scuing form, do differently present the Images to the Eye, as four Eyes, two Mouths, two Noses; sometimes three Eyes, one Mouth, and one Nose, the one large, and the other long; sometimes two Eyes onely, with the Mouth and the Nose deformed, which the Glass (impenetrable) will not shew. And if there be an interior solid Angle, according to the difference of it, (as if it be more sharp) there will be represented two distinct double Images, that is, two entire Visages, and as the Angle is open, by so much the more the double Images will reunite, and enter one within another, which will present sometimes a whole Visage extended at large, to have four Eyes, two Noses, and two Mouths: and by moving the Glass the Angle will vanish, and so the two superficies will be turned into one, and the duplicity of Images will also vanish, and appear but one onely: and this is easily experimented with two
little

little Glasses of Steel, or such-like, so united that they make divers Angles and Inclinations.

THirdly, There are Glasses which make men seem pale, red, and coloured in divers manners, which is caused by the dye of the Glas, or the diverse refraction of the Species: and those which are made of Silver, Latin, Steel, &c. do give the Images a diverse colour also. In which one may see that the appearances by some are made fairer, younger, or older than they are; and contrarily others will make them foul and deformed, and give them a contrary visage: for if a Glas be cut as it may be, or if many pieces of Glas be placed together to make a convenient reflection: there might be made of a Mole (as it were) a Mountain, of one Hair a Tree, a Fly to be as an Elephant, but I should be too long if I should say all that which might be said upon the property of Glasses. I will therefore conclude this Discourse of the properties of these Glasses, with these four recreative Problems following.

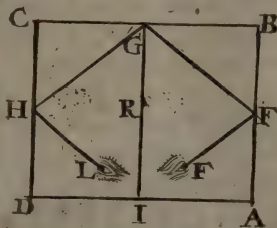
PRO-

PROBLEM LXXVIII.

How to shew to one that is suspicious what is done in another Chamber or Room, notwithstanding the interposition of the Wall.

FOR the performance of this, there must be placed three Glasses in the two Chambers, of which one of them shall be tied to the plinching or feeling, that it may be common to communicate the Species to each Glass by reflection, there being left some hole at the top of the Wall against the Glass to this end: the two other Glasses must be placed against the two Walls at right Angles, as the figure here sheweth at B and C.

Then the sight at E by the line of incidence FE, shall fall upon the Glass BA, and reflect upon the superficies of the Glass BC, in the



point G; so that if the Eye be at G, it should see E, and E would reflect upon the third Glass in the point H, and the Eye that is at L will see the Image that is at E in the point of the Catheti: which Image shall

shall come to the eye of the suspicious, viz at L. by help of the third Glass, upon which is made the second reflection, and so brings unto the eye the object, though a wall be between it.

COROLLARY 1.

BY this invention of Reflections the besiegers of a Town may be seen upon the Rampart : notwithstanding the Parapet, which the besieged may do, by placing a Glass in the hollow of the Ditch, and placing another upon the top of the Wall, so that the Line of Incidence coming to the bottom of the Ditch, make an Angle equal to the Angle of Reflection, then by this situation and reflection, the Image of the besiegement will be seen to him is upon the Rampart.

COROLLARY 2.

BY which also may be inferred, that the same Reflections may be seen in a Regular Polygon, and placing as many Glasses as there are sides, counting two for one ; for then the object being set to one of the Glasses, and the eye in the other, the Image will be seen easily.

COROLLARY 3.

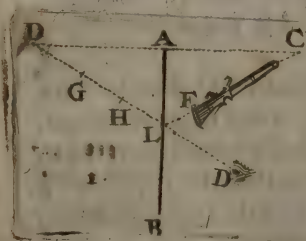
FArther, notwithstanding the interposition of many Walls, Chambers, or Cabinets, one may see that which passeth through the most remotest of them, by placing of many Glasses,
M as

as there are openings in the Walls, making them to receive the incident Angles equal: that is, placing them in such sort by some Geometrical assistant, that the incident points may meet in the middle of the Glasses: but here all the defect will be, that the Images passing by so many reflections, will be very weak, and scarce observable.

PROBLEM LXXIX.

How with a Musket to strike a mark, not looking towards it, as exact as one aiming at it.

AS let the Eye be at O , and the mark C , place a plain Glass perpendicular as AB , so the mark C shall be seen in *Catheti* CA , viz. in D ,



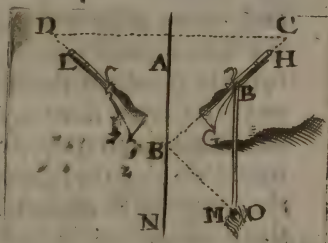
and the Line of Reflection is D , now let the Musket FE , upon a rest, be moved to and fro, until it be seen in the line OD , which admit to be HG , so giving fire to the Musket, it shall undoubtedly strike the Mark.

CORO-

COROLLARIES.

From which may be gathered, that one may exactly shoot out of a Musket to a place which is not seen, being hindered by some Obstacle, or other interposition.

AS let the Eye be at *M*, the mark *C*, and the Wall which keeps it from being seen, admit to be *QR*, then set up a plain Glass, as *AB*, and let the Musket be *GH*, placed upon his rest *B* *O*. Now because the mark *C* is seen at *D*, move the Musket to and fro, until it doth agree with the Line of Reflection *MB*, which suppose at *LI*, so shall it be truly placed, and giving fire to the Musket, it shall not fail to strike the said mark at *C*.

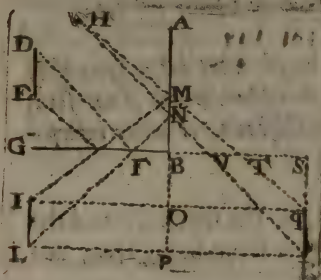


PROBLEM LXXX.

*How to make an Image to be seen hanging in the air,
having his Head downward.*

TAke two Glasses, and place them at right Angles one unto the other, as admit AB , and CB , of which admit CB Horizontal, and

let the Eye be at *H*, and the Object or Image to



be *DE*; so *D* will be reflected at *F*, so to *N*, so to *HE*: then at *G*, so to *M*, and then to *H*, and by a double reflection *E* *D* will seem in *QR*, the highest point *D* in *R*, and the point *E* in *Q* inversed as was

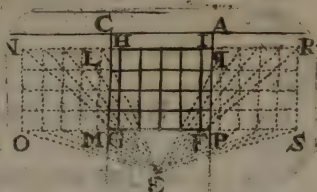
said, taking *D* for the head, and *E* for the feet; so it will be a man inversed, which will seem to be flying in the air, if the Image had wings unto it, and had secretly some motion: and if the Glass were big enough to receive many Reflections, it would deceive the sight the more by admiring the changing of colours that would be seen by that motion.

PROBLEM LXXXI.

How to make a Company of representative Souldiers seem to be a Regiment, or how few in number may be multiplied to seem to be many in number.

TO make the Experiment upon men, there must be prepared two great Glasses; but in stead of it we will suppose 2 lesser, as *GH*, & *FI*, one placed right against another perpendicular to the Horizon, upon a plain level Table: between which

which Glasses let there be ranged in Battalia-wise upon the same Table a number of small men according to the square *G, H, I, F*, or in any other form or posture: then may you evidently see how the said Battel will be multiplied and seem far bigger in the appearance, than it is in effect.



COROLLARY.

BY this invention you may make a little Cabinet of four foot long, and two foot large, (more or less) which being filled with Rocks or such-like things, or there being put into it Silver, Gold, Stones of lustre, Jewels, &c. and the Walls of the said Cabinet being all covered, or hung with plain Glass; these visibles will appear manifoldly increased, by reason of the multiplicity of reflections; and at the opening of the said Cabinet, having set something which might hide them from being seen, those that look into it will be astonished to see so few in number, which before seemed to be so many.

PROBLEM LXXXII.

Of fine and pleasant Dyals.

COULD you choose a more ridiculous one than the natural Dyal written amongst the Greek Epigrams, upon which some sound Poet made verses, shewing that a man carrieth about him always a Dyal in his Face by means of the Nose and Teeth? And is not this a jolly Dyal? For he need not but open the Mouth, the Lines shall be all the Teeth, and the Nose shall serve for the Style,

Of a Dyal of Herbs.

CAN you have a finer thing in a Garden, or in the middle of a Compartment, than to see the Lines and the number of Hours represented with little bushie Herbs, as of Hysop, or such which is proper to be cut in the borders; and at the top of the Style to have a Fan to shew which way the wind bloweth? This is very pleasant and useful.

Of the Dyal upon the Fingers and the Hand.

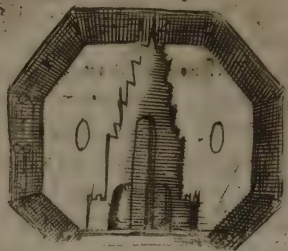
IS it not a commodity very agreeable, when one is in the field or in some village, without any other Dyal, to see onely by the hand what of the clock

clock it is? which gives it very near; and may be practised by the left hand, in this manner.

Take a Straw or like thing of the length of the *Index*, or the second finger; hold this Straw very right between the Thumb and the fore Finger, then stretch forth the hand, and turn your back and the palm of your hand towards the Sun; so that the shadow of the muscle which is under the Thumb touch the Line of Life, which is between the middle of the two other great Lines, which is seen in the palm of the hand, this done, the end of the shadow will shew what of the clock it is: for at the end of the first Finger it is 7 in the morning, or 5 in the evening, at the end of the Ring-Finger it is 8 in the morning, or 4 in the evening; at the end of the Little Finger or first Joynt, it is 9 in the morning, or 3 in the afternoon, 10 and 2 at the second Joynt, 11 and 1 at the third Joynt, and mid-day in the Line following, which comes from the end of the *Index*.

Of a Dial which was about an Obelisk at Rome.

WAS not this a pretty fetch upon a Pavement, to choose an *Obelisk* for a *Dial*, having 106 foot in height, without removing the Basis of it? *Pliny* assures us in his 26 Book and 8 Chap. that the Emperour *Augustus* having accommodated in the Field of *Mars* an *Obelisk* of this height, he made about it a Pavement, and by the industry of *Manilius* the Mathematician, there were enched marks of Copper upon the Pavement,



ment, and placed also an Apple of Gold upon the top of the said *Obelisk*, to know the hour and the course of the Sun, with the increase and decrease of days by the same shadow; and in the same manner do some by the shadow of their head or other Style, make the like Experiments in Astronomy.

Of Dyals with Glasses.

PTolomy writes, as *Cardanus* reports, that long ago there were Glasses which served for Dyals, and presented the face of the beholder as many times as the hour ought to be; 2 if it were 2 of the clock, 9 if it were 9, &c. But this was thought to be done by the help of water, & not by Glasses, which did leak by little and little out of the vessel, discovering first 1 Glass, then 2 Glasses, then 3, 4, 5 Glasses, &c. to shew so many faces as there were hours, which was onely by leaking of water.

Of a Dial which hath a Glass in place of the Style.

WHat will you say of the invention of Mathematicians, which find out daily so many fine and curious Novelties? They have now a way to make Dyals upon the Wainscot or Seeling of a Chamber, and there where the Sun can never shine,

shine, or the beams of the Sun cannot directly strike: and this is done in placing of a little Glass in the place of the Style, which reflecteth the light with the same condition that the shadow of the Style sheweth the hour: and it is easie to make experiment upon a common Dyal, changing only the disposition of the Dyal, and tying to the end of the Style a piece of plain Glass. The *Almains* use it much, who by this way have no greater trouble, but to put their Noses out of their Beds and see what a clock it is, which is reflected by a little hole in the Window upon the Wall or Sieling of the Chamber.

Examination.

IN this there are two Experiments considerable, the first is with a very little Glass placed so that it may be open to the Beams of the Sun, the other hath respect to a spacious or great Glass placed to a very little hole, so that the Sun may shine on it, for then the shadow which is cast upon the Dyal is converted into beams of the Sun, and will reflect and be cast upon a plain opposite: and in the other it is a hole in the Window, or such-like, by which may pass the Beams of the Sun, which represent the extremity of the Style, and the Glass representeth the plain of the Dyal, upon which the beams being in manner of shadows reflect cast upon a plain opposite: and it is needful that in this second way the Glass may be spacious, as before, to receive the delineaments of the Dyal.

Other-

Otherwise you may draw the Lineaments of a Dy-
al upon any plain Looking-Glass which reflecteth the
Sun-beams, for the applying a Style or a Pearl at the
extremity of it; and placed to the Sun, the reflection
will be answerable to the delineaments on the Glass:
but here note, that the Glass ought to be great, and so
the delineaments thereon.

But that which is most Noble, is to draw hori-
zontal lines upon the out-side of the Glass of a Window,
and placing a Style thereto upon the out-side, the
shadow of the Style will be seen within, and so you
have the hour more certain, without any difficulty.

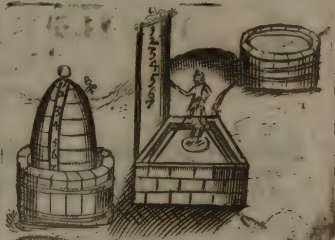
Of Dyals with Water.

Such kind of Dyals were made in ancient
times, and also those of Sand: before they
had skill to make Sun-Dyals, or Dyals with
Wheels: for they used to fill a Vessel with Wa-
ter, and having experience by trial that it would
run out all in a day, they did mark within the
Vessel the hours noted by the running of the Wa-
ter; and some did set a piece of light board in
the Vessel to swim upon the top of the Water,
carrying a little Statue, which with a small stick
did point out the hour upon a Column or Wall,
figured with hour-notes, as the Vessel was figu-
red within.

Viruvius writes of another manner of Water-
Dyal more difficult; and *Baptista à Porta* amongst
his Natural Secrets, delivers this Invention fol-
lowing: Take a Vessel full of Water like a Cal-
dron, and another Vessel of Glass like unto a Bell,
(with

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(with which some accustom to cover *Melons*) and let this Vessel of Glas be almost as great as the Caldron, having a small hole at the bottom, then when it is placed upon the water, it will sink by little and little: by this one may mark the hours on the surface of the Glas to



serve another time. But if at the beginning one had drawn the water within the same Vessel of Glas in sucking by the little hole, the water would not fall out, but as fast as the air would succeed it, entering slowly at the little hole: for contrarily the hours may be distinguished by diminution of water, or by augmentation.

Now it seems a safer way that the water pass out by drop and drop, and drop into a Cylindrical Glas by help of a Pipe: for having marked the exterior part of the Cylinder in the hour-notes, the Water it self which falls within it will shew what of the clock it is, far better than the running of Sand; for by this may you have the parts of the hours most accurate, which commonly by Sand is not had: and to which may be added the hours of other Countries with greater ease. And here note, that as soon as the Water is out of one of the Glasses, you may turn it over into the same again out of the other, and so let it run anew.

PRO-

PROBLEM LXXXIII.

*Of Cannons or great Artillery.**Souldiers and others would willingly see this Problem, which contains 3 or 4 subtile Questions.*

I.

The first is, How to charge a Cannon without Powder.

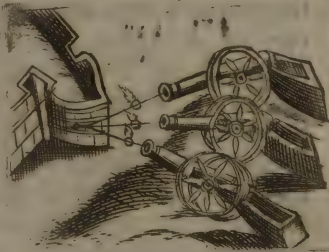
THIS might be done with air and water only, having thrown cold water into the Cannon, which might be squirted forceably in by the closure of the mouth of the Piece, that so by this pressure the air might more condense; then having a round piece of Wood very just, and oiled well, for the better to slide, and thrust the Bullet when it shall be time: This piece of Wood may be held fast with some Pole, for fear it be not thrust out before his time: then let fire be made about the *Trunion* or hinder part of the Piece to heat the air and water, and then when one would shoot it, let the pole be quickly loosened, for then the air searching a greater place, and having way now offered, will thrust out the Wood and the Bullet very quick: The Experiment which we have in long Trunks shooting out pellets with air only, sheweth the verity of this Problem.

2. In

2.

In the second Question it may be demanded, How much time doth the Bullet of a Cannon spend in the air before it falls to the ground ?

THe Resolution of this Question depends upon the goodness of the Piece and Charge thereof, seeing in each there is great difference. It is reported that *Ticho Brabe*, and the *Landsgrave* did make an Experiment upon a Cannon in *Germany*, which being charged and shot off, the Bullet spent 2 min. of time in the air before it fell: and the distance was a German mile, which distance proportionated to an hours time, makes 120 Italian miles.



3.

In the third Question it may be asked, How it comes to pass, that a Cannon shooting upward, the Bullet flies with more violence than being shot point-blank, or shooting downward ?

IF we regard the effect of a Cannon when it is to batter a Wall, the Question is false, seeing it is most evident that the blows which fall
Per-

Perpendicular upon a Wall, are more violent than those which strike byas-wise or glancingly.

But considering the strength of the blow only, the Question is most true, and often experimented to be found true: a Piece mounted at the best of the Randon, which is near half of the right, conveys her Bullet with a far greater violence than that which is shot at point blank, or mounted parallel to the Horizon. The common reason is, that shooting high, the fire carries the bowl a longer time in the air, and the air moves more facil upwards than downwards, because that the airy circles that the motion of the Bullet makes, are soonest broken. Howsoever this be the general Tenet, it is curious to find out the inequality of moving of the air; whether the Bullet fly upward, downward, or right forward, to produce a sensible difference of motion; and some think that the Cannon being mounted, the Bullet pressing the powder maketh a greater resistance, and so causeth all the powder to be inflamed before the Bullet is thrown out, which makes it to be more violent than otherwise it would be. When the Cannon is otherwise disposed, the contrary arrives, the fire leaves the Bullet, and the Bullet rolling from the Powder resists less: and it is usually seen, that shooting out of a Musket charged onely with Powder, to shoot to a mark of Paper placed point blank, that there are seen many small holes in the Paper, which cannot be other than the grains of Powder which did not take fire: but this latter accident may happen from the overcharging of the Piece, or the length

length of it, or windy, or dampness of the Powder.

From which some may think that a Cannon pointed right to the *Zenith*, should shoot with greater violence than in any other mount or form whatsoever : and by some it hath been imagined that a Bullet shot in this fashion hath been consumed, melted, and lost in the air, by reason of the violence of the blow, and the activity of the fire, and that sundry Experiments have been made in this nature, and the Bullet never found. But it is hard to believe this assertion : it may rather be supposed that the Bullet falling far from the Piece cannot be discerned where it falls, and so comes to be lost.

4.

In the fourth place it may be asked, Whether the discharge of a Cannon be so much the greater, by how much it is longer ?

IT seemeth at the first to be most true, that the longer the Piece is, the more violent it shoots : and to speak generally, that which is direction by a Trunk, Pipe, or other concavity, is conveyed so much the more violent, or better, by how much it is longer, either in respect of the Sight, Hearing, Water, Fire, &c. and the reason seems to hold in Cannons, because in those that are long, the fire is retained a longer time in the concavity of the Piece, and so throws out the Bullet with more violence, and experience lets us see that taking

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taking Cannons of the same bore, but of diversity of length from 8 foot to 12, that the Cannon of 9 foot long hath more force than that of 8 foot long, and 10 more than that of 9, and so unto 12 foot of length. Now the usual Cannon carries 600 Paces, some more, some less, yea some but 200 Paces from the Piece, and may shoot into soft earth 15 or 17 foot, into sand or earth which is loose, 22 or 24 foot, and in firm ground, about 10 or 12 foot, &c.

It hath been seen lately in *Germany*, where there were made Pieces from 8 foot long to 17 foot of like bore, that shooting out of any piece which was longer than 12 foot; the force was diminished, and the more in length the Piece increaseth, the less his force was: therefore the length ought to be in a mean measure, and it is often seen the greater the Cannon is, by so much the service is greater: but to have it too long or too short, is not convenient, but a mean proportion of length to be taken, otherwise the flame of the fire vwill be overpressed vvith Air, vvhich hinders the motion in respect of substance, and distance of getting out.

PROBLEM LXXXIV.

Of prodigious Progression and Multiplication of Creatures, Plants, Fruits, Numbers, Gold, Silver, &c. when they are always augmented by certain proportion.

Here we shall shew things no less admirable than recreative, and yet so certain and easie to be demonstrated, that there needs not but Multiplication onely, to try each particular: and first,

Of Grains of Mustard-seed.

First, Therefore it is certain that the increase of one grain of Mustard seed for 20 years space, cannot be contained within the visible World, nay if it were an hundred times greater than it is: and holding nothing besides from the Centre of the Earth even unto the Firmament, but onely small Grains of Mustard-seed: Now because this seems but words, it must be proved by Art, as may be done in this wise: As suppose one Mustard-seed sown to bring forth a Tree or Branch, in each extendure of which might be a thousand grains: but we will suppose onely a thousand in the whole Tree, and let us proceed to 20 years, every Seed to bring forth yearly a thousand grains; now multiply-

N

ing

ing always by a thousand, in less than 17 years, you shall have so many grains which will surpass the sands, which are able to fill the whole Firmament: for following the supposition of *Archimedes*, & the most probable opinion of the greatness of the Firmament which *Ticho Brahe* hath left us; the number of grains of Sand will be sufficiently expressed with 49 Cyphers, but the number of grains of Mustard-seed at the end of 17 years will have 52 Cyphers: and moreover, grains of Mustard-seed are far greater than these of the Sands: It is therefore evident that at the seventeenth year, all the grains of Mustard-seed which shall successively spring from one grain onely, cannot be contained within the limits of the whole Firmament; what should it be then, if it should be multiplied again by a thousand for the eighteenth year, and that again by a thousand for every years increase, until you come to the twentieth year? It's a thing as clear as the day, that such a heap of Mustard-seed would be an hundred thousand times greater than the Earth: and bring onely but the increase of one grain in twenty years.

Of Pigs.

SEcondly, Is it not a strange Proposition, to say, That the Great Turk with all his Revenues, is not able to maintain for one years time all the Pigs that a Sow may pig with all her Race, that is, the increase with the increase, unto 12 years: this seems impossible, yet it is most true, for

for let us suppose and put the case, that a Sow bring forth but 6, 2 Males and 4 Females, and that each Female shall bring forth as many every year, during the space of 12 years, at the end of the time there will be found above 33 millions of Pigs: Now allowing a crown for the maintenance of each Pig for a year, (which is as little as may be, being but near an half of a farthing allowance for each day) there must be at least so many crowns to maintain them one year, viz. 33 millions, which exceeds the Turks Revenue by much.

Of Grains of Corn.

THirdly, It will make one astonished to think that a Grain of Corn with his increase successively, for the space of 12 years will produce in Grains 244140625000000000000, which is able to load almost all the Creatures in the World.

To open which, let it be supposed that the first year one grain being sowed brings forth 50, (but sometimes there is seen 70, sometimes 100 fold) which grains sown the next year, every one to produce 50, and so consequently the whole and increase to be sown every year, until 12 years be expired, there will be of increase the aforesaid prodigious sum of grains, viz. 244140625000000000000, which will make a Cubical Heap of 6258522 Grains every way, which is more than a Cubical Body of 31 miles every way: for allowing 40 grains in length to

each foot, the Cube would be 156463 foot every way : from which it is evident that if there were two hundred thousand Cities as great as *London*, allowing to each 3 miles square every way, and 100 foot in height, there would not be sufficient room to contain the aforesaid quantity of Corn : and suppose a Bushel of Corn were equal unto two cubick feet, which might contain twenty hundred thousand grains, then would there be 122070462500000 bushels, and allowing 30 bushels to a Tun, it would be able to load 8138030833 Vessels, which is more than eight thousand one hundred and thirty eight millions, ship loadings of 500 Tun to each Ship : a quantity so great, that the Sea is scarce able to bear, or the Universal World able to find Vessels to carry it. And if this Corn should be valued at half a Crown the bushel, it would amount to 15258807812500 pounds Sterling, which I think exceeds all the Treasures of all the Princes, and of other particular men in the whole World : And is not this good Husbandry to sow one grain of Corn, and to continue it in sowing the increase onely for 12 years, to have so great a profit ?

Of the Increase of Sheep.

Fourthly, Those that have great flocks of sheep may be quickly rich, if they would preserve their Sheep without killing or selling of them : so that every Sheep produce one each year, for at the end of 16 years 100 Sheep will multiply and increase

increase unto 6553600, which is above six millions, five hundred fifty three thousand Sheep: Now supposing them worth but a crown a piece, it would amount unto 1638400 pounds Sterling, which is above 1 million 6 hundred 38 thousand pounds. A fair increase of one Sheep, and a large portion for a Child, if it should be allotted.

Of the increase of Cod-fish, Carps, &c.

Fifthly, If there be any creatures in the world that do abound with increase or fertility, it may be rightly attributed to fish; for they in their kinds produce such a great multitude of Eggs, and bring forth so many little ones, that if a great part were not destroyed continually, within a little while they would fill all the Sea, Ponds, and Rivers in the World; and it is ealie to shew how it would so come to pass, onely by supposing them to increase without taking or destroying them for the space of 10 or 12 years: having regard to the solidity of the Waters, which are allotted for to lodge and contain these Creatures, as their bounds and place of rest to live in.

Of the increase and multiplication of Men.

Sixthly, There are some that cannot conceive how it can be that from eight persons (which were saved after the Deluge or Noahs Flood) should spring such a World of People to begin

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a Monarchy under *Nimrod*, being but 200 years after the Flood, and that amongst them should be raised an Army of 200000 fighting men: But it is easily proved if we take but one of the Children of *Noah*, and suppose that a new Generation of People began at every 30 years, and that it be continued to the seventh Generation, which is 200 years; for then of one only Family there would be produced 111000 Souls, 305 to begin the World: though in that time men lived longer, and were more capable of multiplication and increase: which number springing onely from a simple production of one yearly, would be far greater if one Man should have many Wives, which in ancient times they had: from which it is also that the Children of *Israel*, who came into *Egypt* but only 70 Souls, yet after 210 years captivity, they came forth with their Hosts, that there were told 600000 fighting men, besides old People, Women, and Children; and he that shall separate but one of the Families of *Joseph*, it would be sufficient to make up that number: How much more should it be then, if we should joyn many Families together?

Of the Increase of Numbers.

Seventhly, What sum of money shall the City of *London* be worth, if it should be sold, and the money be paid in a year after this manner: The first week to pay a Pin, the second week 2 Pins, the third week 4 Pins, the fourth week 8 Pins,

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Pins, the fifth week 16 Pins, and so doubling until the 52 Weeks, or the year be expired?

Here one would think that the value of the Pins would amount but to a small matter, in comparison of the Treasures or Riches of the whole City: Yet it is most probable that the number of Pins would amount unto the sum of 4519599628681215, and if we should allow unto a quarter a hundred thousand Pins, the vvhole vvhould contain ninety eight millions, four hundred thousand Tun: vvhich is able to load 45930 Ships of a thousand Tun apiece: And if vve should allow 1000 Pins for a Penny, the sum of money vvhould amount unto above eighteen thousand eight hundred and thirty millions of pounds sterling: An high Price to sell a City at, yet certain, according to that first proposed.

So if 40 Towns were sold upon condition to give for the first a penny, for the second 2 pence, for the third 4 pence, &c. by doubling all the rest unto the last, it would amount unto this number of pence 1099511627776, which in pounds is 4581298444, that is, four thousand five hundred, and fourscore millions of pounds, and more.

Of a man that gathered up Apples, Stones, or such-like, upon a condition.

Eightly, Admit there were 100 Apples, Stones, or such-like things, that were plac'd in a straight line or right form, a Pace one from another, and a basket being placed a Pace from the first: how many Paces would there be made to put all these Stones into the Basket, by fetching one by one? This would require near half a day to do it, for there would be made 10092 paces before he should gather them all up.

Of Changes in Bells, in Musical Instruments, Transmutation of places in Numbers, Letters, Men, or such-like.

Ninthly, Is it not an admirable thing to consider how the Skill of Numbers doth easily furnish us with the knowledge of mysterious and hidden things? which simply look'd into by others that are not versed in Arithmetick, do present unto them a world of confusion and difficulty.

As in the first place it is often debated amongst our common Ringers, what number of Changes there might be made in five, six, seven, eight, or more Bells: who spend much time to answer their own doubts, entering often into a Labyrinth in the search thereof: or if there were 10 Voices, how many several notes might there be? These are propositions of such facility, that a Child which can but multiply one number by another, may easily resolve it, which is but onely

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to multiply every number from the unite succes-
sively in each others product, unto the term as-
signed : so the 6 number that is against 6 in the
Table, is 720, and so many Changes may be made
upon 6 Bells, upon 5 there are 120, &c.

1	a	1
2	b	2
3	c	6
4	d	24
5	e	120
6	f	720
7	g	5040
8	h	40320
9	i	362880
10	k	3628800
11	l	39916800
12	m	479001600
13	n	6227020800
14	o	87178291200
15	p	1307674368000
16	q	20922789888000
17	r	355687537996000
18	r	6402375683928000
19	t	121645137994632000
20	u	2432902759892640000
21	tw	51090957957745440000
22	x	1124001075070399680000
23	y	25852024726619192640000
24	z	620448593438860623360000

In like manner against 10 in the Table is
3628800, that is, three millions, six hundred
twenty

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twenty eight thousand, eight hundred ; which shews that 10 Voices may have so many Conforts, each man keeping his own note, but onely altering his place ; and so of stringed Instruments, and the *Gamat* may be varied according to which, answerable to the number that is against *r*, viz.

1124001075070399680000 Notes.

From which may be drawn this or the like Proposition :

Suppose that 7 Schollars were taken out of a Free School to be sent to an University, there to be entertained in some Colledge at Commons for a certain sum of money, so that each of them have two meals daily, and no longer to continue there, then that sitting all together upon one Bench or Form at every Meal, there might be a divers transmutation of place of account in some one of them, in comparison of another, and never the whole company to be twice alike in situation: How long may the Steward entertain them? (who being not skilled in this fetch, may answer unadvisedly.) It is most certain that there will be five thousand and forty several positions or changings in the seatings, which makes fourteen years time, wanting ten weeks and three days.

Hence from this mutability of transmutation, it is no marvel that by 24 Letters there ariseth and is made such variety of Languages in the World, and such infinite number of words in each Language; seeing the diversity of Syllables produceth that effect, and also by the interchanging and placing of Letters amongst the Vowels, and amongst

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amongst themselves maketh these syllables, which Alphabet of 24 Letters may be varied so many times, viz. 620448593438860623360000, which is six hundred twenty thousand, four hundred forty eight millions of millions of millions five hundred ninety three thousand, four hundred thirty eight millions of millions, and more.

Now allowing that a man may read or speak one hundred thousand words in an hour, which is twice more words than there are contained in the Psalms of *David*, (a Task too great for any man to do in so short a time) and if there were four thousand six hundred and fifty thousand millions of men, they could not speak these words (according to the hourly proportion aforesaid) in threecore and ten thousand years; which variation and transmutation of Letters, if they should be written in Books, allowing to each Leaf 28000 words, (which is as many as possibly could be inserted) and to each Book a Ream or 20 Quire of the largest and thinnest Printing-Paper, so that each Book being about 15 inches long, 12 broad, and 6 thick: The Books that would be made of the transmutation of the twenty four Letters aforesaid, would be at the least 3877803789928788: And if a Library of a mile square every way, of 50 foot high, were made to contain 250 Galleries of 20 foot broad apiece, it would contain four hundred millions of the said Books: so there must be to contain the rest no less than 96945092 such Libraries; and if the Books were extended over the surface of the

the Globe of the Earth, it would be a decuple covering unto it, a thing seeming most incredible, that 24 Letters in their transmutation should produce such a prodigious number, yet most certain and infallible in computation.

Of a Servant hired upon certain conditions.

A Servant said unto his Master, that he would dwell with him all his life-time, if he would but only lend him land to sow one grain of Corn with all his increase for 8 years time; how think you of this bargain? For if he had but a quarter of an inch of ground for each grain, and each grain to bring forth yearly an increase of 40 grains the whole sum would amount unto, at the term aforesaid, 6553600000000 grains: and seeing that 3 thousand and 6 hundred millions of inches do but make one mile square in the superficies, it shall be able to receive 14 thousand and 4 hundred millions of grains, which is 14400000000, thus dividing the aforesaid 6553600000000, the Quotient will be 455, and so many square miles of land must there be to sow the increase of one grain of Corn for 8 years, which makes at the least 420000 Acres of Land, which rated but at five shillings the Acre *per Annum*, amounts unto 1000000 pound; which is 12500 pound a year, to be continued for 8 years: a pretty pay for a Masters Servant 8 years service.

PRO-

PROBLEM LXXXV.

Of Fountains, Hydriatiques, Mackineck, and other Experiments upon Water or other Liquor.

I.

First how to make Water at the Foot of a Mountain to ascend to the Top of it, and so to descend on the other side.

TO do this there must be a Pipe of Lead, which may come from the Fountain *A*, to the top of the Mountain *B*; and so to descend on the other side, a little lower than the Fountain, as at *C*, then make a hole in the Pipe, at the top of the Mountain, as at *B*, and stop the end of the Pipe at *A* and *C*; and fill this Pipe at *B* with Water, and close it very carefully again at *B*, that no Air get in; then unstop the end at *A*, and at *C*; then will the Water perpetually run up the Hill, and descend on the other side, which is an invention of great consequence to furnish Villages that want Water.



2. Secondly,

2.

Secondly, How to know what Wine or other Liquor there is in a Vessel, without opening the Bung-hole, and without making any other hole than that by which it runs out at the top.

IN this Problem there is nothing but to take a bowed Pipe of Glass, and put it into the faucets hole, and stopping it close about : for then you shall see the Wine or Liquor to ascend in this Pipe, until it be just even with the Liquor in the Vessel: by which a man may fill the Vessel, or put more into it: and so if need were, one may empty one Vessel into another, without opening the Bung-hole:

3.

Thirdly, How is it that it is said that a Vessel holds more Water, being placed at the foot of a Mountain, than standing upon the top of it?

THIS is a thing most certain, because that water and all other Liquor disposeth it self spherically about the Centre of the Earth; and by how much the Vessel is nearer the Centre, by so much the more the surface of the Water makes a lesser sphere, and therefore every part more gibbous or swelling than the like part in a greater sphere :

Sphere: and therefore when the same Vessel is farther from the Centre of the Earth, the surface of the water makes a greater sphere, and therefore less *gibbous* or swelling over the Vessel: from whence it is evident that a Vessel near the Centre of the Earth holds more Water than that which is farther remote from it; and so consequently a Vessel placed at the bottom of the Mountain holds more Water, than being placed on the top of the Mountain.

First, Therefore one may conclude, that one and the same Vessel will always hold more, by how much it is nearer the Centre of the Earth.

Secondly, If a Vessel be very near the Centre of the Earth, there will be more Water above the brims of it, than there is within the Vessel.



Thirdly, a Vessel full of Water coming to the Centre will spherically increase, and by little and little leave the Vessel; and passing the Centre, the Vessel will be all emptied.

Fourthly, One cannot carry a Pail of Water from a low place to a higher, but it will more and more run out and over; because that in ascending it lies more level, but descending it swells, and becomes more *gibbous*.

4. Fourthly,

4.

Fourthly, To conduci Water from the top of one Mountain, to the top of another.

AS admit on the top of a Mountain there is a Spring, and at the top of the other Mountain there are Inhabitants which want Water: Now to make a Bridge from one Mountain to another, were difficult, and too great a charge; by way of Pipes it is easie, and of no great price: for if at the Spring on the top of the Mountain be placed a Pipe to descend into the Valley, and ascend to the other Mountain, the Water will run naturally, and continually, provided that the Spring be somewhat higher than the passage of the Water at the Inhabitants.

5.

Fifthly, Of a fine Fountain which spouts Water very high, and with great violence, by turning of a Cock.

LEt there be a Vessel as *AB*, made close in all his parts, in the middle of which let *CD* be a Pipe open at *D* near the bottom, and then with a Squirt squirt in the Water at *C*, stopped above by the Cock or Faucet *C*, with as great violence as possible you can; and turn the Cock

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immediatly. Now there being an indifferent quantity of Water and Air in the Vessel, the Water keeps it self in the bottom, and the Air which was greatly pressed, seeks for

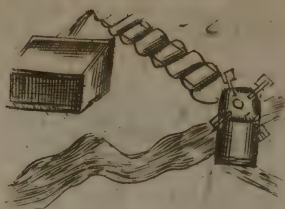


more place, that turning the Cock, the Water issueth forth at the Pipe, and flies very high, and that especially if the Vessel be a little heated. Some make use of this for an Ewer to wash hands withall, and therefore putting a moveable Pipe above C, such as the Figure sheweth: which the Water will cause to turn very quick, pleasurable to behold.

6.

Sixthly, Of Archimedes's Screw, which makes Water ascend by descending.

THis is nothing else but a Cylinder, about the which is a Pipe in form of a Screw, and when one turns it, the Water descends always in respect of the Pipe: for it passeth from one part which is higher to that which is lower, and at the end of the Engine the Water is found higher than it was at the Spring. This great Engineer, admirable in all Mathematical Arts, invented this Instrument to wash King Hieroies
O great



great Vessels, as some Authors say, also to water the fields of Egypt, as *Diodorus* witnesseth: and *Cardanus* reporteth that a Citizen of Milan having made the like Engine, thinking

himself to be the first Inventer, conceived such exceeding joy, that he became mad, *Fol. 2.*

Again, A thing may ascend by descending, if a spiral Line be made, having many circulations or revolutions; the last being always lesser than the first, yet higher than the Plain supposed: It is most certain that then putting a Ball into it, and turning the spiral Line so, that the first circulation may be perpendicular, or touch always the supposed Plain, the Ball shall in descending continually ascend, until at last it come to the highest part of the spiral Line, and so fall out. And here especially may be noted, That a moving Body, as Water, or a Bullet, or such-like, will never ascend, if the Helical Revolution of the Screw be not inclining to the Horizon: so that according to this Inclination the Ball or Liquor may descend always by a continual motion and revolution. And this Experiment may be more useful naturally made with a Thread of Iron or Latine, turned or bowed Helically about a Cylinder, with some distinction of distances between the *Helices*, for then having drawn out the Cylinder, or having hung or tied some weight at it, in such

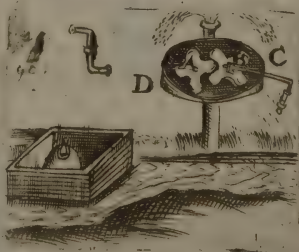
fort

fort that the Water may easily drop if one lift up the said Thread: these *Helices* or Revolutions notwithstanding will remain inclining to the Horizon, and then turning it about forward, the said weight will ascend; but backward, it will descend. Now if the Revolutions be alike, and of equality amongst themselves, and the whirling or turning motion be quick, the sight will be so deceived, that producing the action it will seem to the ignorant no less than a Miracle.

7.

Seventhly, Of another fine Fountain of Pleasures.

THis is an Engine which hath two Wheels with Cogges or Teeth, as *A B*, which are placed within an Oval *C D*, in such sort, that the Teeth of the one may enter into the Notches of the other; but so just, that neither Air nor Water may enter into the Oval Coffe, either by the middle, or by the sides, for the Wheel must joyn so near to the sides of the Coffe, that there be no vacuity: To this there is an Axletree with a handle to each Wheel, so that they may be turned, and *A* being turned, that turneth the other Wheel that is opposite: by which motion the air that is in *E*, and the water that is carried by



O 2

the

the hollow of the Wheels of each side, by continual motion, is constrained to mount and flie out by the Funnel F. Now to make the Water run what way one would have it, there may be applied upon the top of the Pipe F, two other moveable Pipes inserted one within another; as the Figure sheweth. But here note that there may acruce some inconveniency in this Machine, seeing that by quick turning the Cogs or Teeth of the Wheels running one against another, may near break them, and so give way to the Air to enter in, which being violently inclosed will escape to occupy the place of the Water, whose weight makes it so quick: howsoever, if this Machine be curiously made as an able Workman may easily do, it is a most soveraign Engine, to cast Water high and far off for to quench fires. And to have it to rain to a place assigned, accommodate a Socket having a Pipe at the middle, which may point towards the place, being set at the top thereof, and so having great discretion in turning the Axis of the Wheel, it may work exceeding well, and continue long.

8.

Eighly, Of a fine Watering-Pot for Gardens.

THIS may be made in form of a Bottle, according to the last figure, or such-like, having at the bottom many small holes, and at the neck of it another hole somewhat greater than those

those at the bottom, which hole at the top you must unstop when you would fill this Watering-Pot, for then it is nothing but putting the lower end into a Pail of Water; for so it will fill it self by degrees: and being full, put your Thumb on the hole at the Neck to stop it, for then may you carry it from place to place, and it will not sensibly run out; something it will, and all in time, (if it were never so close stopped) contrary to the ancient Tenet in Philosophy, That Air will not penetrate.

9.

Ninthly, How easily to take Wine out of a Vessel at the Bung-hole, without piercing of a hole in the Vessel.

IN this there is no need but to have a Cane or Pipe of Glass, or such-like, one of the ends of which may be closed up almost, leaving some small hole at the end; for then if that end be set into the Vessel at the Bung-hole, the whole Cane or Pipe will be filled by little and little; and once being full, stop the other end which is without, and then pull out the Cane or Pipe, so will it be full of Wine, then opening a little the top above, you may fill a Glass or other Pot with it, for as the Wine issueth out, the air cometh into the Cane or Pipe, to supply vacuity,



O 3

10. Tenthly,

Tenthly, How to measure irregular Bodies by help of Water.

Some throw in the Body or Magnitude into a Vessel, and keep that which floweth out over, saying it is always equal to the thing cast into the Water: But it is more neater this way, to pour into a Vessel such a quantity of Water, which may be thought sufficient to cover the Body or Magnitude, and make a mark how high the Water is in the Vessel, then pour out all this Water into another Vessel, and let the Body or Magnitude be placed into the first Vessel; then pour in Water from the second Vessel until it ascend unto the former mark made in the first Vessel, so the Water which remains in the second Vessel, is equal to the Body or Magnitude put into the Water: But here note that this is not exact or free from error, yet nearer the Truth than any Geometrician can otherwise possibly measure; and these Bodies that are not so full of pores, are more truly measured this way, than others are.

To find the Weight of Water.

Seeing that $\frac{174}{1000}$ part of an ounce weight, makes a Cubical Inch of Water, and every pound weight *Haverdupoiz* makes 27 Cubical Inches

Inches, and $1\frac{2}{3}$ fere, and that 7 Gallons and a half Wine-measure makes a foot Cubical, it is easie by inversion, that knowing the quantity of a Vessel in Gallons to find his content in Cubical feet or weight : and that late famous Geometrician Master *Brigs* found a Cubical Foot of Water to weigh near 62 pound weight *Haverdupoiz*. But the late Learned *Simon Stevin* found a Cubical Foot of Water to weigh 65 pound ; which difference may arise from the inequality of Water ; for some Waters are more ponderous than others ; and some difference may be from the weight of a pound, and the measure of a Foot. Thus the weight and quantity of a solid foot settled, it is easie for Arithmeticians to give the contents of Vessels or Bodies which contain Liquids.

12.

To find the Charge that a Vessel may carry, as Ships, Boats, or such-like.

THis is generally conceived, that a Vessel may carry as much weight as that Water weigheth which is equal unto the Vessel in bigness, in abating only the weight of the Vessel : We see that a Barrel of Wine or Water cast into the Water, will not sink to the bottom, but swim easily ; and if a Ship had not Iron and other ponderosities in it, it might swim full of Water without sinking : In the same manner if the Vessel were laden with Lead, so much should the Water

ter weigh: Hence it is that Mariners call Ships of 50000 Tuns, because they may contain one or 2000 Tun, and so consequently carry as much.

13.

How comes it that a Ship having safely sailed in the vast Ocean, and being come into the Port or Harbour, without any tempest will sink down right?

THe cause of this is, That a Vessel may carry more upon some kind of Water than upon other; now the Water of the Sea is thicker and heavier than that of Rivers, Wells, or Fountains; therefore the loading of a Vessel which is accounted sufficient in the Sea, becomes too great in the Harbour; or Sweet Water. Now some think that it is the depth of the Water that makes Vessels more easie to swim, but it is an abuse: for if the loading of a Ship be no heavier than the Water that would occupy that place, the Ship should as easily swim upon that Water, as if it did swim upon a thousand fathom deep of Water; and if the Water be no thicker than a leaf of Paper, and weigheth but an ounce under a heavy body, it will support it, as well as if the Water under it weighed ten thousand pound weight: Hence it is, if there be a Vessel capable of a little more than a thousand pound weight of Water, you may put into this Vessel a piece of Wood which shall weigh a thousand pound weight; (but lighter in his kind than the like magnitude of Water) for

for then pouring in but a quart of Water, or a very little quantity of Water, the Wood will swim on the top of it, (provided that the Wood touch not the sides of the Vessel) which is a fine Experiment, and seems admirable in the performance.

14.

How a gross Body of Metal may swim upon the Water.

THis is done by extending the Metal into a thin Plate, to make it hollow in form of a Vessel; so that the greatness of the Vessel which the air with it containeth, be equal to the magnitude of the Water, which weighs as much as it, for all Bodies may swim without sinking, if they occupy the place of Water equal in weight unto them, as if it weighed 12 pound, it must have the place of 12 pound of Water: Hence it is that we see floating upon the Water great Vessels of Copper or Brass, when they are hollow in form of a Caldron. And how can it be otherwise conceived of Islands in the Sea, that swim and float? Is it not that they are hollow and some part like unto a Boat, or that their Earth is very light and spongy, or having many Concavities in the Body of it, or much Wood within it.

And it would be a pretty proposition to shew how much every kind of Metal should be enlarged to make it swim upon the Water: which

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which doth depend upon the proportion that is between the weight of the Water and each Metal. Now the proportion that is between Metals and Water of equal magnitude, according to some Authors, is as followeth:

A magnitude of 10 pound weight of Water will require for the like magnitude of	GOLD	187½
	LEAD	116½
	SILVER	104
	COPPER	91
	IRON	81
	TINNE	75

From which is inferred, That to make a piece of Copper of 10 pound weight to swim, it must be made so hollow that it may hold 9 times that weight of Water, and somewhat more, that is to say 91 pound: Seeing that Copper and VVater of like magnitudes in their ponderosities, are as before, as 10 to 91.

15.

How to weigh the lightness of the Air.

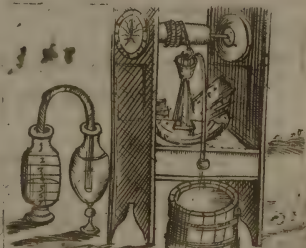
Place a Ballance of wood turned upside down into the water, that so it may swim, then let water be inclosed within some body, as within a Bladder or such-like, and suppose that such a quantity of Air should weigh one pound, place it under one of the Ballances, and place under the other as much weight of lightness as may counter-balance and keep the other Ballance that it

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it rise not out of the water: by which you shall see how much the lightness is.

But without any Ballance do this :

Take a Cubical hollow Vessel, or that which is Cylindrical, which may swim on the water, and as it sinketh by placing of weights upon it,



mark how much, forthen if you would examine the weight of any body, you have nothing to do but to put it into this Vessel, and mark how deep it sinks : for so many pound it weighs as the weights put in do make it so to sink.

16.

A Body being given, to mark it about, and shew how much of it will sink in the Water, or swim above the Water.

THis is done by knowing the weight of the Body which is given, and the quantity of Water, which weighs as much as that body ; for then certainly it will sink so deep, until it occupieth the place of that quantity of Water.

17. To

17.

To find how much several Metals or other Bodies do weigh less in the Water than in the Air.

TAKE a Ballance, and weigh (as for example) 9 pound of Gold, Silver, Lead, or Stone, in the Air, so it hang in *equilibrio*; then coming to the Water, take the same quantity of Gold, Silver, Lead or Stone, and let it softly down into it, and you shall see that you shall need a less Counterpoise in the other Ballance to counter-balance it: Wherefore all Solids or Bodies weigh less in the Water than in the Air, and so much the less it will be, by how much the Water is gross and thick because the weight finds a greater resistance, and therefore the Water supports more than Air; and further, because the Water by the ponderosity is displeased, and so strives to be there again, pressing to it, by reason of the other Waters that are about it, according to the proportion of his weight. *Archimedes* demonstrateth, that all Bodies weigh less in the Water (or in like Liquor) by how much they occupy place: and if the Water weigh a pound weight, the magnitude in the Water shall weigh a pound less than in the Air.

Now by knowing the proportion of Water and Metals, it is found that Gold loseth in the Water the 19 part of his weight, Copper the 9 part, Quicksilver the 15 part, Lead the 12 part, Silver the 10 part, Iron the 8 part, Tin the 7 part and

and a little more : wherefore in material and absolute weight, Gold in respect of the Water that it occupieth weigheth 18 and $\frac{3}{4}$ times heavier than the like quantity of Water, that is, as 18 $\frac{3}{4}$ to the Quicksilver 15 times, Lead 11 and $\frac{2}{5}$, Silver 10 and $\frac{2}{3}$, Copper 9 and $\frac{1}{10}$, Iron 8 and $\frac{1}{2}$, and Tin 8 and $\frac{1}{3}$. Contrarily in respect of greatness, if the Water be as heavy as the Gold, then is the Water almost 19 times greater than the magnitude of the Gold, and so you may judge of the rest.

18.

How is it that a Ballance having like weight in each Scale, and hanging in æquilibrio in the Air, being placed in another place, (without removing any weight) it shall cease to hang in æquilibrio sensibly, yea by a great difference of weight ?

THIS is easie to be resolved by considering different Metals, which though they weigh equal in the Air, yet in the Water there will be an apparent difference ; as suppose so that in the Scale of each Ballance be placed eighteen pound weight of several Metals, the one Gold, and the other Copper, which being in æquilibrio in the Air, placed in the Water will not hang so, because that the Gold loseth near the eighteenth part of his weight, which is about one pound, and the Copper loseth but his ninth part, which is two pound : wherefore the Gold in the water

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water weigheth but 17 pound, and the Copper 16 pound, which is a difference most sensible to confirm that point.

19.

To shew what Waters are heavier one than another, and how much.

Physicians have an especial respect unto this, judging that water which is lightest is most healthful and medicinal for the Body, and Seamen know that the heaviest waters do bear most. And it is known which water is heaviest thus : Take a piece of Wax, and fasten Lead unto it, or some such-like thing, that it may but precisely swim, for then it is equal to the like magnitude of water, then put it into another Vessel which hath contrary water, and if it sink, then is that water lighter than the other : But if it sink not so deep, then it argueth the water to be heavier or more grosser than the first water ; or one may take a piece of Wood, and mark the quantity of sinking of it into several waters, by which you may judge which is lightest or heaviest, for in that which it sinks most, that is infallibly the lightest, and so contrarily.

20. How

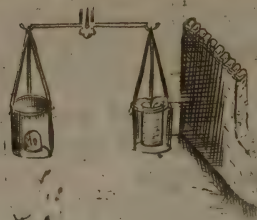
*How to make a pound of Water weigh as much as
10, 20, 30, or 100 pound of Lead; nay as much
as 1000 or 10000 pound weight.*

THis Proposition seems very impossible, yet Water inclosed in a Vessel, being constrained to dilate it self, doth weigh so much as though there were in the concavity of it a solid body of Water.

There are many ways to experiment this Proposition, but to verifie it, it may be sufficient to produce two excellent ones onely: which had they not been really acted, little credit might have been given unto it.

The first way is thus: Take a Magnitude which takes up as much place as 100 or 1000 pound of Water, and suppose that it were tied to something that it may hang in the Air; then make a Ballance that one of the Scales may inviron it, yet so that it touch not the sides of it, but leave space enough for one pound of Water: Then having placed 100 pound weight in the other Scale, throw in the Water about the Magnitude, so that one pound of Water shall weigh down the 100 pound in the other Ballance.

The second way is yet more admirable: Take a common Ballance that is capable to receive 10 or 20 pound of Water, then put into it a magnitude which may take up the place of 9 or 19 pound
of



of water, which must be hung at some Iron or beam which is placed in a wall; so that it hang quiet: (now it is not material whether the magnitude be hollow or massie) so that

it touch not the Balance in which it is put, for then having put the Lead or Weight into the other Ballance, pour in a pound of Water into the Ballance where the Magnitude is, and you shall see that this one pound of Water shall counterpoise the 10 or 20 pound of Lead which is set in the other Ballance.

PROBLEM LXXXVI.

Of sundry Questions in ARITHMETICK.

And first of the Number of Sands.

IT may be said incontinent, that to undertake this were impossible, either to number the Sands of *Lybia*, or the Sands of the Sea; and it was this that the Poets sung, and that vvhich the Vulgar believes; nay, that vvhich long ago certain Philosophers to *Gelon* King of *Sicily* reported, that the grains of Sand vvere innumerable. But I answer vvith *Archimedes*, that not onely one

one may number those which are at the border, and about the Sea, but those which are able to fill the whole world, if there were nothing else but Sand, and the grains of Sands admitted to be so small, that 10 may make but one grain of Poppy: for at the end of the account there need not to express them but this number 30840979456, and 35 Cyphers at the end of it. *Clavius* and *Archimedes* make it somewhat more, because they make a greater Firmament than *Ticho Brahe* doth; and if they augment the Universe, it is easie for us to augment the number, and declare assuredly how many grains of Sand there are requisite to fill another World, in comparison that our visible World were but as one grain of Sand, an atom, or a point; for there is nothing to do but to multiply the number by it self, which will amount to 90 places, whereof twenty are these: 95143798134910955936, and 70 Cyphers at the end of it, which amounts to a most prodigious number, and is easily supputated: for supposing that a grain of Poppy doth contain 10 grains of Sand, there is nothing but to compare that little bowl of a grain of Poppy, with a bowl of an inch or of a foot, and that to be compared with that of the Earth, and then that of the Earth with that of the Firmament, and so of the rest.

2.

Divers Metals being melted together in one body, to find the mixture of them.

THis was a notable Invention of *Archimedes*, related by *Vitruvius* in his *Architecture*, where he reporteth that the Goldsmith which King *Hiero* imployed for the making of the Golden Crown which was to be dedicated to the Gods, had stolen part of it, and mixed Silver in the place of it: The King suspicious of the work proposed it to *Archimedes*, if by Art he could discover without breaking of the Crown, if there had been made mixture of any other Metal with the Gold. The way which he found out was by bathing himself; for as he entred into the Vessel of Water (in which he bathed himself) so the Water ascended or flew out over it; and as he pulled out his Body, the Water descended: from which he gathered that if a Bowl of pure Gold, Silver, or other Metal, were cast into a Vessel of Water, the Water proportionally, according to the thing cast in, would ascend; and so by way of Arithmetick the Question lay open to be resolved: who being so intensively taken with the invention, leaps out of the Bath all naked, crying as a man transported, *I have found, I have found*, and so discovered it.

Now some say that he took two Masses, the one of pure Gold, and the other of pure Silver; each equal to the weight of the Crown, and therefore unequal in magnitude or greatness; and then
knowing

knowing the several quantities of water which was answerable to the Crown, and the several Masses, he subtilly collected, that if the Crown occupied more place within the water than the Mass of Gold did, it appeared that there was Silver or other Metal melted with it. Now by the Rule of Position, Suppose that each of the three Masses weighed 18 pound apiece, and that the Mass of Gold did occupy the place of one pound of water, that of Silver a pound and a half, and the Crown one pound and a quarter onely: Then thus he might operate: The Mass of Silver which weighed 18 pounds, cast into the Water, did cast out half a pound of water more than the Mass of Gold which weighed 18 pound; and the Crown which weighed also 18 pound, being put into a Vessel full of water, threw out more water than the Mass of Gold by a quarter of a pound, (because of mixt Metal which was in it) therefore by the Rule of Proportion, If half a pound of water (the Excess) be answerable to 18 pound of Silver, one quarter of a pound of Excess shall be answerable to 9 pound of Silver, and so much was mixed in the Crown.

Some judge the way to be more facil by weighing the Crown first in the air, then in the water; in the air it weighed 18 pound, and if it were pure Gold, in the water it would weigh but 17 pound; if it were Copper it would weigh but 16 pound; but because we will suppose that Gold and Copper is mixed together, it will weigh less than 17 pound, yet more than 16 pound, and that according to the proportion mixed: let it then be sup-

posed that it weighed in the water 16 pound and 3 quarters, then might one say by proportion, If the difference of one pound of loss (which is between 16 and 17) be answerable to 18 pound, to what shall one quarter of difference be answerable to, which is between 17 and $16\frac{1}{4}$, and it will be 4 pound and a half, and so much Copper was mixed with the Gold.

Many men have delivered sundry ways to resolve this proposition, since *Archimedes* invention, and it were tedious to relate the diversities.

Baptista Benedictus, amongst his Arithmetical Theorems, delivers his way thus : if a Mass of Gold of equal bigness to the Crown, did weigh 20 pound, and another of Silver, at a capacity or bigness at pleasure, as suppose did weigh 12 pound, the Crown or the mixt body would weigh more than the Silver, and lesser than the Gold : Suppose it weighed 16 pound, which is 4 pound less than the Gold by 8 pound; then one may say, If 8 pound of difference come from 12 pound of Silver, from whence comes 4 pound, which will be 6 pound, and so much Silver was mixed in it, &c.

3.

Three men bought a quantity of Wine, each paid alike, and each was to have alike; it happened at the last partition that there were 21 Barrels, of which 7 were full, 7 were half full, and 7 empty, how must they share the Wine and Vessels, that each have as many Vessels one as another, and as much Wine one as another?

THis may be answered two ways as followeth, and these numbers, 2, 2, 3, or 3, 3, 1, may serve for direction, and signifies that the first person ought to have 3 Barrels full and as many empty ones, and one which is half full; so he shall have 7 Vessels, and 3 Barrels and an half of Liquor; and one of the other shall in like manner have as much, so there will remain for the third man 1 Barrel full, 5 which are half full, and 1 empty, and so every one shall have alike both in Vessels and Wine. And generally to answer such Questions, divide the number of Vessels by the number of persons, and if the Quotient be not an intire number, the Question is impossible; but when it is an intire number, there must be made as many parts as there are 3 persons, seeing that each part is less than the half of the said Quotient: as dividing 21 by 3 there comes 7 for the Quotient, which may be parted in these 3 parts, 2, 2, 3, or 3, 3, 1, each of which being less than half of 7.

4.

There is a Ladder which stands upright against a Wall of 10 foot high, the foot of it is pulled out 6 foot from the Wall upon the Pavement : How much hath the top of the Ladder descended ?

The answer is, 2 foot : for by Pythagoras Rule the square of DB , the Hypotenuſal is equal to the square of DA 6, and AB 10. Now if DA be 6 foot, and AB 10 foot, the squares are 36, and 100, which 36 taken from 100, reſts 64, whose root-quadrate is 8, so the foot of the

Ladder being now at D , the top will be at C , two foot lower than it was when it was at B .



PROBLEM LXXXVII.

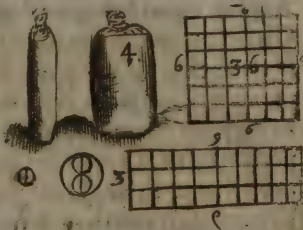
Witty Suits or Debates between Caius and Sempromius, upon the form of Figures, which Geometricians call Isoperimeter, or equal in circuit or compass.

Marvel not at it, if I make the Mathematicks take place at the Bar, and if I set forth here Bartoleus, who witnesſeth of himſelf, that

that being then an ancient Doctor in the Law, he himself took upon him to learn the Elements and Principles of Geometry, by which he might set forth certain Laws touching the divisions of Fields, Waters, Islands, and other incident places: Now this shall be to shew in passing by, that these Sciences are profitable and behoveful for Judges, Counsellors, or such, to explain many things which fall out in Laws, to avoid ambiguities, contentions, and suits often.

The first Incident.

Caius had a Field which was directly square, having 24 measures in circuit, that was 6 on each side: *Sempronius* desiring to fit himself, prayed *Caius* to change with him for a field which should be equivalent unto his, and the bargain being concluded, he gave him for Counter-change a piece of Ground which had just as much in circuit as his had, but it was not square, yet *Quadrangular* and *Rectangled*, having 9 measures in length for each of the two longest sides, and 3 in breadth for each shorter side: Now *Caius* which was not the most subtillest nor wisest in the world, accepted his bargain at the first, but afterwards having conferred with a Land-measurer and Mathematician, found that



he was over-reached in his bargain, and that his Field contained 36 square measures, and the other Field had but 27 measures, (a thing easie to be known by multiplying the length by the breadth) *Sempronius* contested with him in suit of Law, and argued that Figures which have equal *Perimeter*, or *Circuit*, are equal amongst themselves: My Field, saith he, hath equal circuit with yours, therefore it is equal unto it in quantity. Now this was sufficient to delude a Judge which was ignorant in Geometrical Proportions, but a Mathematician will easily declare the deceit, being assured that figures which are *Isoperemiter*, or equal in circuit, have not always equal capacity or quantity: seeing that with the same circuit there may be infinite figures made, which shall be more and more capable, by how much they have more Angles, equal sides, and approach nearer unto a Circle, (which is the most capablest Figure of all) because that all his parts are extended one from another, and from the middle or centre as much as may be: so we see by an infallible Rule of Experience, that a Square is more capable of quantity, than a Triangle of the same circuit, and a Pentagone more than a Square, and so of others, so that they be regular Figures that have their sides equal; otherwise there might be that a regular Triangle having 24 measures in circuit, might have more capacity than a rectangled Parallelogram, which had also 24 measures of circuit, as if it were 11 in length, and 1 in breadth, the circuit is still 24, yet the quantity is but 11; and if it had 6 every way, it gives the same

Peri-

Perimeter, viz. 24, but a quantity of 36, as before.

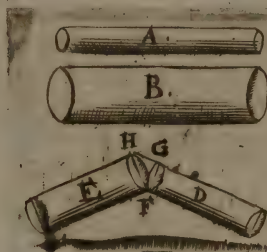
The Second Incident.

Sempronius having borrowed of Caius a Sack of Corn, which was 6 foot high, and 2 foot broad, and when there was question made to repay it, Sempronius gave Caius back two Sacks full of Corn which had each of them 6 foot high, and 1 foot broad : who believed that if the Sacks were full, he was repaid ; and it seems to have an appearance of truth, barely looked on. But it is most evident in demonstration, that the 2 Sacks of Corn paid by Sempronius to Caius, is but half of that one Sack which he lent him : for a Cylinder or Sack having one foot of diameter and 6 foot of length, is but the fourth part of another Cylinder, whose length is 6 foot, and his diameter is 2 foot : therefore two of the lesser Cylinders or Sacks is but half of the greater ; and so Caius was deceived in half his Corn.

The Third Incident.

Some one from a common Fountain of a City hath a Pipe of Water of an inch diameter ; to have it more commodious he hath leave to take as much more water ; whereupon he gives order that a Pipe be made of two inches diameter. Now you will say presently, that it is reason to be so big, to have just twice as much

much water as he had before: but if the Magistrate of the City understood Geometrical Proportions, he would soon cause it to be amended, and shew that he hath not onely taken twice as



much water as he had before, but four times as much: for a circular hole which is two inches diameter, is four times greater than that of one inch, and therefore will cast out

four times as much water as that of one inch, and so the deceit is double also in this.

Moreover, if there were a heap of Corn of 20 foot every way, which was borrowed to be paid next year: the party having his Corn in heaps of 12 foot every way, and of 10 foot every way, proffers him 4 heaps of the greater, or 7 heaps of the lesser, for his own heap of 20 every way, which was lent: Here it seems that the proffer is fair, nay with advantage, yet the loss would be near 1000 foot. Infinite of such causes do arise from Geometrical Figures, which are able to deceive a Judge or Magistrate, which is not somewhat seen in *Mathematical Documents*.

PRO-

PROBLEM LXXXVIII.

Containing sundry Questions in matter of Cosmography.

First, It may be demanded where is the middle of the World? I speak not here Mathematically, but as the vulgar People, who ask, Where is the middle of the World? In this sence to speak absolutely there is no point which may be said to be the middle of the surface; for the middle of a Globe is every where: notwithstanding the Holy Scriptures speak respectively, and make mention of the middle of the Earth, and the Interpreters apply it to the City of *Jerusalem*, placed in the middle of *Palestina*, and the habitable world, that in effect taking a Map of the World, and placing one foot of the Compasses upon *Jerusalem*, and extending the other foot to the extremity of *Europe*, *Asia*, and *Africa*, you shall see that the City of *Jerusalem* is as a Centre to that Circle.

2.

How much is the depth of the Earth, the height of the Heavens, and the compass of the World?

From the surface of the Earth unto the Centre according to ancient traditions, is 3436 miles, so the whole thickness is 6872 miles, of which
the

the whole compass or circuit of the Earth is 21600 miles.

From the Centre of the Earth to the Moon there is near 56 Semidiameters of the Earth, which is about 192416 miles : unto the Sun there is 1142 Semidiameters of the Earth, that is in miles 3924912 ; from the starry firmament to the Centre of the Earth there is 14000 Semidiameters, that is, 48184000 miles, according to the opinion and observation of that learned *Ti-cho Brahe*.

From these measures one may collect by Arithmetical supputations, many pleasant propositions in this manner :

First, If you imagine there were a hole through the Earth, and that a Mill-stone should be let fall down into this hole, and to move a mile in each minute of time, it would be more than two days and a half before it would come to the Centre, and being there it would hang in the Air.

Secondly, If a man should go every day 20 miles, it would be three years wanting but a fortnight, before he could go once about the Earth; and if a Bird should fly round about it in two days, then must the motion be 450 miles in an hour.

Thirdly, The Moon runs a greater compass each hour, than if in the same time she should run twice the Circumference of the whole Earth.

Fourthly, Admit it be supposed that one should go twenty miles in ascending towards the Hea-

vens

vens every day, he should be above fifteen years, before he could attain to the Orb of the Moon.

Fifthly, The Sun makes a greater way in one day than the Moon doth in 20 days, because that the Orb of the Suns Circumference is at the least twenty times greater than the Orb of the Moon.

Sixthly, If a Mill-stone should descend from the place of the Sun a thousand miles every hour; which is above 15 miles in a minute, far beyond the proportion of motion) it would be above 163 days before it would fall down to the Earth.

Seventhly, The Sun in his proper Sphere moves more than seven thousand five hundred and seventy miles in one minute of time : now there is no Bullet of a Cannon, Arrow, Thunderbolt, or Tempest of Wind that moves with such quickness.

Eighthly, It is of a far higher nature to consider the exceeding and unmoveable quickness of the starry firmament, for a Star being in the *Aequator*, (which is just between the Poles of the World) makes 12598666 miles in one hour, which is two hundred nine thousand nine hundred and seventy four miles in one minute of time : and if a Horseman should ride every day 40 miles, he could not ride such a compass in a Thousand Years, as the Starry Firmament moves in one hour, which is more than if one should move about the Earth a thousand times in one hour, and quicker than possible thought
can

can be imagined : and if a Star should fly in the Air about the Earth with such a prodigious quickness, it would burn and consume all the World here below. Behold therefore how time passeth, and death hasteth on : This made *Copernicus* not unadvisedly to attribute this motion of *Primum mobile* to the Earth, and not to the starry Firmament ; for it is beyond humane sense to apprehend or conceive the rapture and violence of that motion, being quicker than thought ; and the Word of God testifieth that the Lord made all things in *Number, Measure, Weight, and Time.*

PROBLEM XCII.

To find the Bissextile-Year, the Dominical-Letter, and the Letters of the Month.

Let 123, or 124, or 125, or 26, or 27, (which is the remainder of 1500, or 1600) be divided by 4, which is the number of the Leap-year, and that which remains of the division shews the Leap-year ; as if one remain, it shews that it is the first year since the Bissextile or Leap year ; if two, it is the second year, &c. and if nothing remain, then it is the Bissextile or Leap-year : and the Quotient shews you how many Bissextiles or Leap-years, there are contained in so many years.

To

To find the Circle of the Sun by the Fingers.

L Et 123, 24, 25, 26, or 27, be divided by 28, (which is the Circle of the Sun, or whole revolution of the Dominical Letters) and that which remains is the number of Joynts which is to be accounted upon the Fingers, by *Filius esto Dei, calum bonus accipe gratis* : and where the number ends, that Finger sheweth the year which is present, and the words of the Verse shew the *Dominical Letter*.

Example.

Divide 123 by 28 for the year (and so of other years) and the Quotient is 4, and there remaineth 11, for which you must account 11 words: *Filius esto Dei, &c.* upon the Joynts, beginning from the first joynt of the *Index*, and you shall have the answer.

For the present to know the *Dominical Letter* for each month, account from *January* unto the month required, including *January*, and if there be 8, 9, 7, or 5, you must begin upon the end of the Finger from the Thumb, and account, *Adam degebat, &c.* as many words as there are months, for then one shall have the Letter which begins the month; then to know what day of the month it is, see how many times 7 is comprehended in the number of days, and take the rest, suppose 4, account upon the first finger within and without by the joynts, unto the number of 4, which ends
at

at the end of the Finger : from whence it may be inferred that the day required was *Wednesday*, *Sunday* being attributed to the first Joynt of the first Finger or Index : and so you have the present year, the Dominical Letter, the Letter which begins the Month, and all the days of the Month.

PROBLEM XCIII.

To find the New and Full Moon in each Month.

Add to the Epact for the year the Month from *March*, then subtract that surplus from 30, and the rest is the day of the Month that it will be New Moon, and adding unto it 14, you shall have that Full Moon.

Note.

That the Epact is made always by adding 11 unto 30, and if it pass 30, subtract 30, and adde 11 to the remainder, and so *ad infinitum* : as if the Epact were 12, add 11 to it, makes 23 for the Epact next year, to which add 11 makes 34, subtract 30, rests 4 the Epact for the year after; and 15 for the year following that, and 26 for the next, and 7 for the next, &c.

PRO-

PROBLEM XCIV.

To find the Latitude of a Countrey.

THose that dwell between the North-Pole and the *Tropick of Cancer*, have their Spring and Summer between the 10 of *March* and the 13 of *September*: and therefore in any day between that time, get the Suns distance by instrumental observation from the Zenith at noon, and add the declination of the Sun for that day to it: So the Aggregate sheweth such is the latitude or Poles height of that Countrey. Now the declination of the Sun for any day is found out by Tables calculated to that end: or Mechanically by the Globe, or by Instrument it may be indifferently had. And here note, that if the day be between the 13 of *September* and the 10 of *March*, then the Suns declination for that day must be taken out of the distance of the Sun from the Zenith at noon: so shall you have the Latitude, as before.

PROBLEM XCV.

Of the Climates of Countreys, and to find what Climate any Countrey is under.

CLimates as they are taken Geographically signifie nothing else but when the length of the next day of any place, is half an hour
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longer or shorter than it is in another place, (and so of the shortest day) and this account to begin from the Equinoctial Circle, seeing all Countreys under it have the shortest and longest day that can be but 12 hours; But all other Countreys that are from the Equinoctial Circle either towards the North or South of it unto the Poles themselves, are said to be in some one Climate or other; from the Equinoctial to either of the Poles Circles, (which are in the Latitude of 66 deg. 30 min.) between each of which Polar Circles and the Equinoctial Circle there is accounted 24 Climates, which differ one from another by half an hours time: then from each Polar Circle to each Pole there are reckoned 6 other Climates which differ one from another by a months time: so the whole Earth is divided into 60 Climates, 30 being allotted to the Northern Hemisphere, and 30 to the Southern Hemisphere. And here note, that though these Climates which are between the Equinoctial and the Polar Circles are equal one unto the other in respect of time, to wit, by half an hour; yet the Latitude, breadth, or internal, contained between Climate and Climate, is not equal: and by how much any Climate is farther from the Equinoctial than another Climate, by so much the lesser is the internal between that Climate and the next: so those that are nearest the Equinoctial are largest, and those which are farthest off most contracted: and to find what Climate any Country is under, subtract the length of an Equinoctial day, to wit, 12 hours, from the length of the longest day of that Countrey, the remain-

remainder being doubled shews the Climate : So at *London* the longest day is near 16 hours and a half ; 12 taken from it, there remains 4 hours and a half, which doubled makes 9 half hours, that is, 9 Climates ; so *London* is in the 9 Climate.

PROBLEM XCVI.

Of Longitude and Latitude of the Earth, and of the Stars.

Longitude of a Countrey or place, is an Arch of the *Æquator* contained between the Meridian of the *Azores*, and the Meridian of the place, and the greatest Longitude that can be is 360 degrees.

Note, That the first Meridian may be taken at pleasure upon the Terrestrial Globe or Map, for that some of the ancient Astronomers would have it at *Hercules Pillars*, which is at the straights at *Gibraltar* : *Ptolomy* placed it at the *Canary Islands*, but now in these latter times it is held to be near the *Azores*. But why it was first placed by *Ptolomy* at the *Canary Islands*, was, because that in his time these Islands were the farthest Western parts of the World that was then discovered. And why it retains his place now at *St. Michaels* near the *Azores*, is that because of many accurate observations made of late by many expert Navigators and Mathematicians, they have found the Needle there to have no variation, but to point North and South : that is, to each Pole of the

World: And why the Longitude from thence is accounted Eastward, is from the motion of the Sun Eastward, or that *Ptolomy* and others did hold it more convenient to begin from the Western part of the World, and so account the Longitude Eastward from Country to Country that was then known, till they came to the Eastern part of *Asia*, rather than to make a beginning upon that which was unknown: and having made up their account of reckoning the Longitude from the Western part to the Eastern part of the world known, they supposed the rest to be all Sea, which since their deaths hath been found almost to be another habitable World.

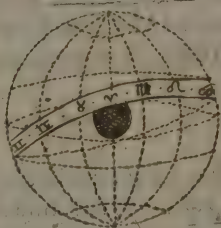
To find the Longitude of a Countrey.

IF it be upon the Globe, bring the Countrey to the Brasen Meridian, and whatsoever degree that Meridian cuts in the Equinoctial, that degree is the Longitude of that Place. If it be in a Map, then mark what Meridian passeth over it, so have you the Longitude thereof; if no Meridian pass over it, then take a pair of Compasses, and measure the distance between the Place and the next Meridian, and apply it to the divided Parallel or *Æquator*, so have you the Longitude required.

Of the Latitude of Countreys.

LAtitude of a Countrey is the distance of a Countrey from the Equinoctial, or it is an Ark of the Meridian contained between the Zenith of the place and the *Æquator*, which is twofold, *viz.* either North-Latitude, or South-Latitude,

tude, either of which extendeth from the Equinoctial to either Pole; so the greatest Latitude that can be is but 90 degrees. If any Northern Countrey have the Artick Circle vertical, which is in the Latitude of 66 gr. 30 m. the Sun will touch the Horizon in the North part thereof, and the longest day will be there then 24 hours: If the Countrey have less Latitude than 66 gr. 30 m. the Sun will rise and set, but if it have more Latitude than 66 gr. 30 m. it will be visible for many days. And if the Countrey be under the Pole, the Sun will make a circular motion above the Earth, and be visible for half a year: so under the Pole there will be but one day and one night in the whole year.



To find the Latitude of Countreys.

IF it be upon a Globe, bring the place to the Brazen Meridian, and the number of degrees which meeteth therewith, is the Latitude of the place: Or with a pair of Compasses take the distance between the Countrey and the Equinoctial, which applied unto the Equi-



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noctial will shew the Latitude of that Countrey, which is equal to the Poles height. If it be upon a Map, then mark what Parallel passeth over the Countrey, and where it crosseth the Meridian, that shall be the Latitude: But if no Parallel passeth over it, then take the distance between the place and the next Parallel, which applied to the divided Meridian from that Parallel will shew the Latitude of that place.

To find the distance of places.

IF it be upon a Globe, then with a pair of *Compasses* take the distance between the two Places, and apply it to the divided Meridian or *Æquator*, and the number of degrees shall shew the distance, each degree being 60 miles. If it be in a Map (according to *Wright's* projection) take the distance with a pair of *Compasses* between the two places, and apply this distance to the divided Meridian on the Map, right against the two places; so as many degrees as is contained between the feet of the *Compasses*, so much is the distance between the two places. If the distance of two places be required in a particular Map, then with the *Compasses* take the distance between the two places, and apply it to the Scale of miles, so have you the distance: If the Scale be too short, take the Scale between the *Compasses*, and apply that to the two places as often as you can, so have you the distance required.

Of the Longitude, Latitude, Declination, and Distance of the Stars.

THe Declination of a Star is the nearest distance of a Star from the *Æquator*; the Latitude of a Star is the nearest distance of a Star from the *Ecliptick*: the Longitude of a Star is an Ark of the *Ecliptick* contained between the beginning of *Aries*, and the Circle of the Stars Latitude, which is a Circle drawn from the Pole of the *Ecliptick* unto the Star, and so to the *Ecliptick*. The distance between two Stars in Heaven is taken by a Cross-Staff, or other Instrument; and upon a Globe it is done by taking between the feet of the Compasses the two Stars, and applying it to the *Æquator*, so have you the distance between those two Stars.

How is it that two Horses or other Creatures being foaled or brought forth into the World at one and the same time, that after certain days travel, the one lived more days than the other, notwithstanding they died together in one and the same moment also?

THis is easie to be answered: Let one of them travel toward the West, and the other towards the East: then that which goes towards the West followeth the Sun, and therefore shall have the day somewhat longer than if there had been no travel made; and that which goes East, by going against the Sun shall have the day short-

er, and so in respect of travel, though they die at one and the self-same hour and moment of time, the one shall be older than the other.

From which consideration may be inferred, That a *Christian*, a *Jew*, and a *Saracen* may have their Sabbaths all upon one and the same day, though notwithstanding the *Saracen* holds his Sabbath upon the *Friday*, the *Jew* upon the *Saturday*, and the *Christian* upon the *Sunday*: For being all three resident in one place, if the *Saracen* and the *Christian* begin their travel upon the *Saturday*, the *Christian* going West, and the *Saracen* Eastwards, shall compass the Globe of the Earth; thus the *Christian* at the conclusion shall gain a day, and the *Saracen* shall lose a day, and so meet with the *Jew* every one upon his own Sabbath.

Certain fine Observations.

I. **U**nder the Equinoctial the Needle hangs in *equilibrio*, but in these parts it inclines under the Horizon; and being under the Pole it is thought it will hang vertical.

II. In these Countreys which are without the Tropical Circles, the Sun comes East and West every day for a half year; but being under the Equinoctial the Sun is never East nor West, but twice in the year, to wit, the 10 of *March*, and the 13 of *September*.

III. If a Ship be in the Latitude of 23 gr. 30 m. that is, if it hath either of the Tropicks vertical; then at what time the Sun's Altitude is equal to his distance from any of the Equinoctial points, then the Sun is due East or West.

IV.

IV. If a Ship be between the Equinoctial and either of the Tropicks, the Sun will come twice to one point of the Compass in the fore-noon, that is in one and the same position.

V. Under the Equinoctial near *Guinea* there is but two sorts of Winds all the year, 6 months a Northerly wind, and 6 months a Southerly wind, and the flux of the Sea is accordingly.

VI. If two Ships under the Equinoctial be 100 leagues asunder, and should sail Northerly until they were come under the Artick Circle, they should then be but 50 leagues asunder.

VII. Those which have the Artick circle vertical, when the Sun is in the Tropick of *Cancer*, the Sun setteth not, but toucheth the western part of the Horizon.

VIII. If the complement of the Suns height at noon be found equal to the Suns Declination for that day, then the Equinoctial is vertical; or a Ship making such an observation, the Equinoctial is in the Zenith, or direct over them, by which Navigators know when they cross the Line, in their travels to the *Indies*, or other parts.

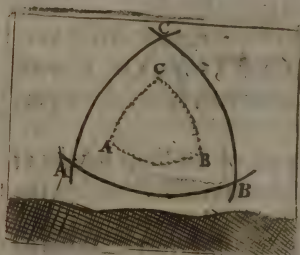
IX. The Sun being in the Equinoctial, the extremity of the Style in any Sun-Dyal upon a Plain maketh a right Line, otherwise it is *Ecliptical*, *Hyperbolical*, &c.

X. When the shadow of a man, or other thing upon a Horizontal Plain, is equal unto it in length then is the Sun in the middle point between the Horizon and the Zenith, that is 45 degrees high.

PROBLEM XCVII.

To make a Triangle that shall have three right Angles.

Open the Compasses at pleasure, and upon *A* describe an Ark *BC*, then at the same opening place one of the feet in *B*, and describe the Ark *AC*. Lastly, Place one of the feet of the Compasses in *C*, and describe the Ark *AB*. So shall you



have the Spherical *Æquilateral Triangle ABC*, right angled at *A*, at *B*, and at *C*, that is, each angle comprehended 90 degrees: which can never be in any plain

Triangle, whether it

be *Æquilateral*, *Isocelse*, *Scaleve*, *Orthogonal*, or *Opigonal*.

PROBLEM XCVIII.

To divide a Line in as many equal parts as one will, without Compasses, or without seeing of it.

This Proposition hath a fallacy in it, and cannot be practised but upon a *Maincordon*: for the Mathematical Line which proceeds from the flux of a point, cannot be divided in that wise:

One

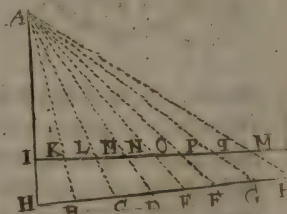
One may have therefore an Instrument which is called *Maincordion*, because there is but one cord : and if you desire to divide your line into 3 parts, run your finger upon the frets until you found a third in Musick : If you would have the fourth part of the Line, then find the fourth sound, a fifth, &c. so shall you have the answer.

PROBLEM XCIX.

To draw a Line which shall incline to another Line, yet never meet, against the Axiome of Parallels.

THis is done by help of a Conoide line, produced by a right line upon one and the same plain, held in great account amongst the Ancients, and it is drawn after this manner.

Draw a right line infinitely, and upon some end of it, as at *I*, draw a perpendicular Line *IA*, augment it to *H*, then from *A* draw Lines at pleasure to intersect the Line *IM*, in each of which Lines from the right Line *IM*, transfer *IH*, viz. *KB*, *LC*, *OD*, *PE*, *QF*, *MG*, then from those points draw the Line *HB*, *CD*, *EFG*, which will not meet with the Line *IM*, and yet incline nearer and nearer unto it.



PRO-

PROBLEM CI.

How to find at any time which way the Wind is in ones Chamber, without going abroad.

UPon the Planking or Floor of a Chamber, Parlor, or Hall where you intend to have this device, let there come down from the top of the House a hollow Post, in which place an Iron Rod, that it ascend above the House ten or six foot with a Vane or Scou-chen at it to shew the winds without : and at the lower end of this rod of iron, place a Dart which may by the moving of the Vane with the Wind without, turn this Dart which is within : about which upon the Plaister must be described a circle divided into the 32 points of the Mariners Compass, pointed and distinguished to that end ; then may it be marked by placing the Compass by it : for having noted the North point, the East, &c. it is easie to note all the rest of the points : and so at any time coming into this room, you have nothing to do but to look up to the Dart, which will point you out what way the Wind bloweth at that instant.



PRO-

PROBLEM CII.

How to draw a Parallel Spherical Line with great ease.

First draw an obscure line GF , in the middle of it make two points, A B , (which serves for Centres) then place one foot of the Compasses in B , and extend the other foot to A , and describe the Semicircle AC ; then place one foot of the Compasses in A , and extend the other foot to C , and describe the Semicircle CD . Now place the Compasses in B , and extend the other foot unto D , and describe the Semicircle DE , and so *ad infinitum*; which being done neatly, that there be



no right line seen, nor where the Compasses were placed, will seem very strange how possibly it could be drawn with such exactness, to such which are ignorant of that way.

PROBLEM CIII.

To measure an inaccessible distance, as the breadth of a River with the help of ones Hat onely.

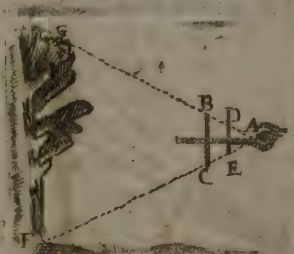
THe way of this is easie: for having ones Hat upon his Head, come near to the Bank of the River, and holding your Head upright, which

(which may be by putting a small stick to some one of your Buttons to prop up the Chin) pluck down the brim or edge of your Hat until you may but see the other side of the water, then turn about the body in the same posture that it was before towards some Plain, and mark where the sight by the brim of the Hat glaunceth on the ground; for the distance from that place to your standing, is the breadth of the River required.

PROBLEM CIV.

How to measure a height with two Straws, or two small Sticks.

TAKE two Straws or two Sticks, which are one as long as another, and place them at right Angles one to the other, as AB , and AC , then holding AB parallel to the ground, place the end A to the Eye at A , and looking to the other top BC at C , by going backward or forward until you may see the top of the Tower or Tree, which suppose at E . So the distance from your standing to the Tower or Tree, is equal to the height thereof above the level of the Eye: to which if you add your own height, you have the whole height.



Other-

Otherwise.

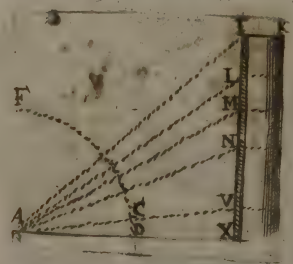
Take an ordinary Square which Carpenters or other Workmen use, as HKL , and placing H to the Eye so that HK be level, go back, or come nearer, until that by it you may see the top M , for then the distance from you to the height, is equal to the height.



PROBLEM CV.

How to make Statues, Letters, Bowls, or other things which are placed in the side of a high Building, to be seen below of an equal bigness.

Let BC be a Pillar 7 yards high, and let it be required that 3 yards above the level of the Eye A , viz. at B , be placed a Globe, and 9 yards above B be placed another, and 22 yards above that be placed another Globe: how much shall the Diameter of these Globes be, that at the Eye at A , they may all appear to be of one and the same magnitude? It is thus done: First draw a line,



line, as AK , and upon K erect a perpendicular, KX ; divide this line into 27 parts, & according to AK , describe an Ark KY , then from K in the perpendicular KX account 3 parts, viz. at L , which shall represent the former 3 yards, and draw the line LA from L , in the said perpendicular reckon the diameter of the lesser Globe of what magnitude it is intended to be: Suppose SL , and draw the line SA , cutting the Ark UK , in N , then from K in the perpendicular account 9 yards, which admit at T , draw TA , cutting YK in O , transfer the Ark MN , from A to P , and draw AP , which will cut the perpendicular in U , so a line drawn from the middle of UF , unto the visual Lines AI , and AU , shall be the diameter of the next Globe: Lastly, Account from K in the perpendicular XK 22 parts, and draw the line WA , cutting YK in Q , then take the Ark MN , and transfer it from Q to R , and draw AR , which will cut the perpendicular in X , so the line which passeth by the middle of XW perpendicular to the visual line AW , and AX be the Diameter of the third Globe, to wit 5, 6, which measures transferred in the Pillar BC , which sheweth the true magnitude of the Globes 1, 2, 3. From this an Architector doth proportion his Images, and the foldings of the Robes which are most deformed at the Eye below in the making, yet most perfect when it is set in his true height above the Eye.

PROBLEM CVI.

How to disguise or disfigure an Image, as a Head, an Arm, a whole Body, &c. so that it hath no proportion; the Ears to become long, the Nose as that of a Swan, the Mouth as a Coaches entrance, &c. yet the Eye placed at a certain point will be seen in a direct and exact proportion.

I Will not strive to set a Geometrical Figure here, for fear it may seem too difficult to understand, but I will endeavour by discourse, how mechanically with a Candle you may perceive it sensible: first there must be made a figure upon Paper, such as you please, according to his just proportion, and paint it as a Picture (which Painters know well enough to do) afterwards put a Candle upon the Table, and interpose this figure obliquely, between the said Candle and the Books of Paper, where you desire to have the figure disguised in such sort that the height pass athwart the hole of the Picture, then will it carry all the form of the Picture upon the Paper, but with deformity; follow these tracts, and mark out the light with a coals black head or Ink, and you have your desire.

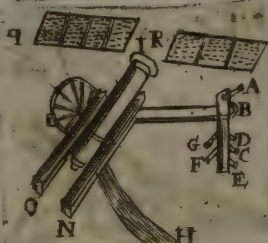
To find now the point where the eye must see it in his natural form: it is accustomed according to the order of Perspective, to place this point in the line drawn in height, equal to the largeness of the narrowest side of the deformed square, and it is by this way that it is performed.

PRO-

PROBLEM CVII.

How a Cannon after that it hath shot, may be covered from the battery of the Enemy.

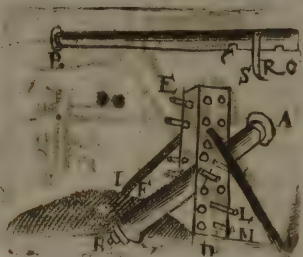
Let the mouth of a Cannon be *I*, the Cannon *M*, his charge *NO*, the Wheel *L*, the Axletree *P B*, upon which the Cannon is placed, at which end towards *B*, is placed a Pillar *A E*, supported with Props, *D, C, E, F G*, about which the Axletree turneth: Now the Cannon being to shoot, it retires to *H*, which cannot be directly, because of the Axletree, but makes a segment of a circle, and hides himself behind the Wall *Q R*, and so preserves it self from the Enemies battery, by which means one may avoid many inconveniences which might arise: and moreover, one man may more easily replace it again for another shot, by help of Poles tied to the Wall, or other help which may multiply the strength.



PROBLEM CVIII.

How to make a Lever, by which one man may alone place a Cannon upon his Carriage, or raise what other weight he would.

First place two thick boards upright, as the figure sheweth, pierced with holes, alike opposite one unto another, as CD and EF, and let L and M be the two Bars of Iron which pass through the holes, GH and FK the 2 supports, or



props, AB the Cannon, OP the Lever, RS the two Notches in the Lever, and Q the Hook which the Burthen or Cannon is tied to. The rest of the operation is

facil, that the youngest Schollars or Learners cannot fail to perform it: to teach *Minerva* were in vain, and it were to Mathematicians injury in the succeeding Ages.

PRO-

PROBLEM CIX.

How to make a Clock with one onely Wheel.

MAKE the body of an ordinary Dyal, and divide the hour in the Circle into 12 parts: make a great Wheel in height above the Axletree, to the which you shall place the Cord of your counterpoize, so that it may descend, that in 12 hours of time your *Index* or *Needle* may make one Revolution, which may be known by a Watch which you may have by you: then put a Ballance which may stop the course of the Wheel, and give it a regular motion, and you shall see an effect as just from this, as from a Clock with many *Wheels*.



PROBLEM CX.

How by help of two Wheels to make a Child to draw up alone a Hogshead of Water at a time; and being drawn up, shall cast out it self into another Vessel, as one would have it.

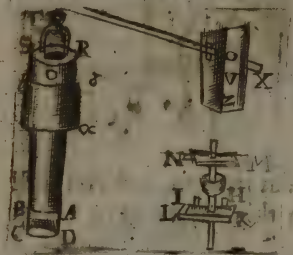
LET R be the Pit from whence Water is to be drawn, P the Hook to throw out the Water when it is brought up, (this Hook must be

R 3

move-

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moveable) let AB be the Axis of the Wheel SF , which Wheel hath divers forks of Iron made at G , equally fastened at the Wheel; let I be a Cord which is drawn by K , to make the Wheel S to turn, which Wheel S bears proportion to the Wheel T , as 8 to 2, let N be a Chain of Iron to which is tied the Vessel O , and the other which is in the Pit EF is a piece of Wood which hath a mortise in 1, and 2, by which the Cord I passeth, tied at the Wall as KH , and the other piece of Timber of the little Wheel, as M , mortised in likewise for the Chain to pass through: Draw the Cord I , by K , and the Wheel will turn, and so consequently the Wheel T , which will cause the



Vessel O to raise; which being empty, draw the Cord again by T , and the other Vessel which is in the Pit will come out by the same reason. This is an invention which will save la-

bour if practised; but here is to be noted that the Pit must be large enough, to the end that it contain two great Vessels to pass up and down one by another.

PRO-

PROBLEM CXI.

To make a Ladder of Cords which may be carried in ones Pocket, by which one may easily mount up a Wall or Tree alone.

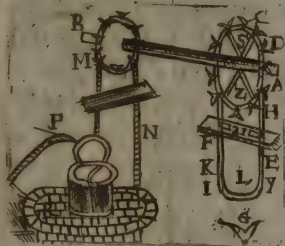
TAKE two Pullies, *A* and *D*, unto that of *A* let there be fastened a Cramp of Iron, as *B*, and at *D* let there be fastened a Staff of a foot and an half long, as *F*, then the Pulley *A*: place a hand of Iron, as *E*, to which tie a cord of an half inch thick, (which may be of Silk because it is for the pocket) then strive to make fast the Pulley *A*, by the help of the Cramp of Iron *B*, to the place that you intend to scale; and the Staff *F* being tied at the Pulley *D*, put it between your legs as though you would sit upon it: then holding the cord *C* in your hand, you may guide your self to the place required: wch may be made more facil by the multiplying of Pullies. This secret is most excellent in War, and for Lovers; its supportableness avoids suspicion.



PROBLEM CXII.

How to make a Pump whose strength is marvellous by reason of the great weight of Water that it is able to bring up at once, and so by continuance.

L Et $\alpha \beta \gamma \delta$ be the height of the case about 2 or 3 foot high, and broader according to discretion: the rest of the case or concavity let be *O*, let the Sucker of the Pump which is made be just for the case or Pump's head, $\alpha \beta \gamma \delta$ and may be made of Wood or Brass of 4 inches thick, having a hole at *E*, which descending raiseth up the cover *P*, by which issueth forth the water, and ascending or raising up, it shuts it or makes it close:



RS is the handle of the Sucker, tied to the handle *TX*, which works in the post *U* *Z*. Let *A, B, C, D*, be a piece of Brass, *G* the piece which enters into the hole to *F*, to keep out the Air; *H*,

I, K, L, the piece tied at the funnel or pipe: in which plays the Iron Rod or Axis *G*, so that it pass through the other piece *MN*, which is tied with the end of the Pipe of Brass.

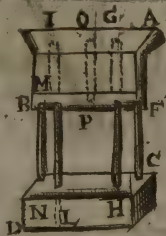
Note, That the lower end of the Cistern ought to be rested upon a Gridiron or Iron Grate, which may be tied in the Pit, by which means lifting up and putting down the handle, you may draw ten times more Water than otherwise you could.

PRO-

PROBLEM CXIII.

How by means of a Cistern to make Water of a Pit continually to ascend without strength, or the assistance of any other Pump.

Let IL be the Pit where one would cause water to ascend continually to each office of a house, or the places which are separated from it: let there be made a Receiver, as A , well closed up with Lead or other matter, that Air enter not in, to which fasten a Pipe of Lead, as at E , which may have vent at pleasure, then let there be made a Cistern, as B , which may be communicative to A , by help of the pipe G , from which Cistern B , may issue the water of Pipe D , which may descend to H , which is a little below the level of the water of the pit, as much as is GH , to the end of which shall be soldered close a cock which shall cast out the water by KH .



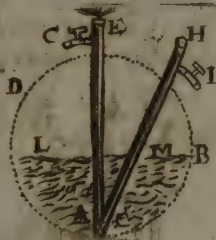
Now to make use of it, let B be filled full of water, and when you would have it run, turn the Cock, for then the water in B will descend by K , and for fear that there should be vacuity, Nature which abhors it, will labour to furnish and supply that emptiness out of the Spring F , and that the Pit dry not, the Pipe ought to be small, of an indifferent capacity, according to the greatness or smallness of the Spring.

PRO-

PROBLEM CXIV.

How out of a Fountain to cast the Water very high, different from a Problem formerly delivered.

L Et the Fountain be BD , of a round form, (seeing it is the most capable and most perfect figure) place into it two Pipes conjoynd, as EA , and HC , so that no air may enter in at the place of joyning: let each of the Pipes have a



cock, G and I , the cock at G being closed, open that at I , and so with a Squirt force the Water through the hole at H , then close the cock at A , and draw out the Squirt, and

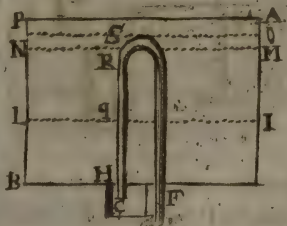
open the cock at G , the air being before rarified will extend his dimensions, and force the Water with such violence, that it will mount above the height of one or two Pipes; and so much the more, by how much the Machine is great: this violence will last but a little while, if the Pipe have too great an opening; for as the Air approacheth to his natural place, so the force will diminish.

PRO-

PROBLEM CXV.

How to empty the Water of a Cistern by a Pipe which shall have a motion of it self.

L Et AB be the Vessel, CDE the Pipe; HG a little Vessel under the greater, in which one end of the Pipe is, viz. C , and let the other end of the Pipe E , passing through the bottom of the Vessel at F , then as the Vessel filleth, so will the Pipe; and when the Vessel shall be full as far as PO , the Pipe will begin to run at E of his own accord, and never cease until the Vessel be wholly empty.



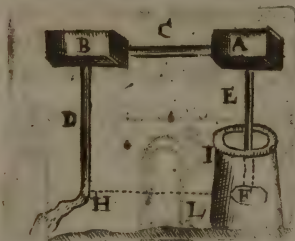
PROBLEM CXVI.

How to squirt or spout out a great height, so that one Pot of Water shall last a long time.

L Et there be prepared two vessels of Brasse, Lead, or of other matter of equal substance, as are the two Vessels AB and BD , and let them be joyned together by the two Pillars MN and EF ; then let there be a Pipe HG , which may pass thorough the cover of the Vessel CD , and pass through AB into G , making a little bunch or rising in the cover of the Vessel AB , so that the Pipe touch it

not

not at the bottom : then let there be soldered fast another Pipe I L, which may be separated from the bottom of the Vessel, and may have his bunchy swelling as the former, without touching the bottom : as is represented in L, & passing through the bottom of A B, may be continued unto I, that



is to say, to make an opening to the cover of the vessel A B, and let it have a little mouth as a Trumpet, to that end to receive the water: then there must further be added a very small pipe

which may pass through the bottom of the Vessel A B, as let it be O P, and let there be a bunch or swelling over it, as at P, so that it touch not also the bottom : let there be further made to this lesser Vessel an edge in form of a Basin to receive the water, which being done, pour water into the Pipe I L, until the Vessel C D be full, then turn the whole Machine up-side-down, that the Vessel C D may be uppermost, and A B undermost; so by help of the Pipe G H, the water of the Vessel C D will run into the Vessel A B, to have passage by the Pipe P O. This motion is pleasant at a feast in filling the said Vessel with Wine, which will spout it out, as though it were from a boiling Fountain in the form of a Thread, very pleasant to behold.

PROBLEM CXVII.

How to practise excellently the re-animation of Simples, in case the Plants may not be transported to be re-planted by reason of distance of places.

TAKE what Simple you please, burn it, and take the Ashes of it, and let it be calcinated 2 hours between 2 Creusets well luted, and extract the Salt: that is, to put water into it in moving of it; then let it settle, and do it two or three times: afterwards evaporate it, that is, let the water be boiled in some Vessel, until it be all consumed: then there will remain a Salt at the bottom, which you shall afterwards sow in good ground well prepared, such as the Theatre of Husbandry sheweth, and you shall have your desire.

PROBLEM CXVIII.

How to make an infallible perpetual motion.

MIX 5 or 6 ounces of Mercury with his equal weight of Jupiter, grind it together with ten or twelve ounces of Sublimate dissolved in a Cellar upon a Marble the space of four days, and it will become like Oil - Olive, which distil with fire of chaff; or driving fire, and it will sublime dry substance, then put water upon the Earth (in form of Lye) which will be at the bottom of the Limbeck, and dissolve that which you can; filter it, then distil it, and there will be produced very subtil Atomes, which put into
a bot-

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a bottle close stopped, and keep it dry, and you shall have your desire, with astonishment to all the World, and especially to those which have travelled herein without fruit.

PROBLEM CXIX.

Of the admirable Invention of making the Philosophers Tree, which one may see with his Eye to grow by little and little.

TAKE two ounces of *Aqua-fortis*, and dissolve in it half an ounce of fine Silver refined in a Cappel: then take an ounce of *Aqua-fortis*, and two drams of Quick-silver, which put in it, and mix these two dissolved things together, then cast into it a Vial of half a pound of Water, which may be well stopped; for then every day you may see it grow both in the Tree and in the branch. This Liquid serves to black hair which is red or white, without fading untill they fall: But here is to be noted that great care ought to be had in anointing the hair, for fear of touching the flesh: for this composition is very corrosive or searching, that as soon as it toucheth the flesh it raiseth blisters and bladders very painful.

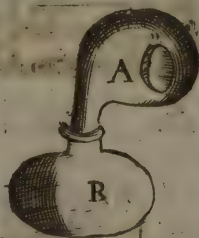
PROBLEM CXX.

How to make the representation of the Great World.

DRAW Salt Nitre out of Salt Earth which is found along the Rivers side, and at the foot of Mountains, where especially are Minerals of Gold

Gold and Silver : mix that Nitre well cleansed with Ψ , then calcinate it hermetically; then put it in a Limbeck, and let the Receiver be of Glass well luted, and always in which let there be placed Leaves of Gold at the bottom, then put fire

under the Limbeck until vapours arise which will cleave unto the Gold; augment your fire until there ascend no more then take away your Receiver, and close it hermetically, and



make a Lamp fire under it, until you see presented in it that which Nature affords us, as *Flowers, Trees, Fruits, Fountains, Sun, Moon, Stars, &c.* Behold here the form of the Limbeck, and the Receiver : *A* represents the Limbeck, *B* stands for the Receiver.

PROBLEM CXXI.

How to make a Cone or Pyramidal Body move upon a Table, without springs or other artificial means; so that it shall move by the edge of the Table without falling.

THIS Proposition is not so thorny and subtle as it seems to be, for putting under a Cone of Paper a Beetle or such-like Creature, you shall have pleasure, with astonishment and admiration to those which are ignorant in the cause: for this
Animal



Animal will strive always to free herself from the captivity in which she is by the imprisonment of the Cone: for coming near the edge of the Table she will return to the

other side, for fear of falling.

PROBLEM CXXII.

To cleave an Anvil with the blow of a Pistol.

THis is proper to a Warriour, and to perform it, let the Anvil be heated red hot as one can possibly, in such sort that all the solidity of the body be softened by the fire: then charge the Pistol with a Bullet of Silver, and so have you infallibly the Experiment.

PROBLEM CXXIII.

How to roast a Capon carried in a Budget at a Saddle-Bow, in the space of riding 5 or 6 miles.

HAVING made it ready and larded it, stuff it with Butter, then heat a piece of Steel, which may be formed round according to the length of the Capon, and big enough to fill the Belly of it, and then stop it with Butter; then wrap it up well, and inclose it in a Box in the Budget, and you shall have your desire: It is said

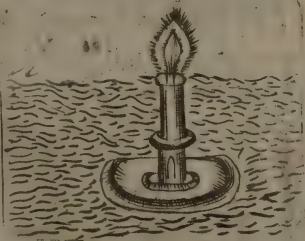
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Count Mansfield served himself with no others, but such as were thus made ready, for that it loseth none of its substance, and it is dressed very equally.

PROBLEM CXXIV.

How to make a Candle burn and continue three times as long as otherwise it would.

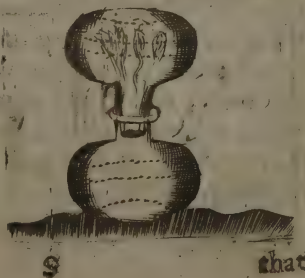
U Nto the end of a Candle half burned stick a farthing, less or more, to make it hang perpendicular in a Vessel of water, so that it swim above the water; then light it, and it will sustain itself, and float in this manner, and being placed into a Fountain, Pond, or Lake that runs slowly, where many people assemble, it will cause an extreme fear to those which come therein in the night, knowing not what it is.



PROBLEM CXXV.

How out of a quantity of Wine to extract that which is most windy and evil, that is hurt not a sick Person.

T Ake 2 vials in such sort that they be of like greatness both in the belly and the neck, fill one of them of wine, and the other of water: let the mouth of



that

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that which hath the water be placed into the mouth of that which hath the wine, so the water shall be uppermost: now because the water is heavier than the wine, it will descend into the other Vial; and the wine which is lowest, because it is lightest will ascend above, to supply the place of the water, & so there will be a mutual interchange of liquids, and by this penetration the wine will lose her vapors in passing through the water.

PROBLEM CXXVI.

How to make two Marmouzets, one of which shall light a Candle, and the other put it out.

UPon the side of a Wall make the figure of a Marmouzet, or other Animal or form, and right against it on the other wall make another; in the mouth of each put a pipe or quill so artificially that it be not perceived; in one of which place Salt-peter very fine, and dry, and pulverised; and at the end set a little match of paper, in the other place Sulphur beaten small, then holding a candle lighted in your hand, say to one of these Images by way of command, *Blow out the Candle*; then lighting the paper with the candle, the Salt-peter will blow out the candle immediately; and going to the other Image (before the match of the candle be out) touch the Sulphur with it, and say, *Light the Candle*, and it will immediately be lighted; which will cause an admiration to those which see the action, if it be well done, with a secret dexterity.

PRO-

PROBLEM CXXVII.

How to keep Wine fresh as if it were in a Cellar, in the heat of Summer, and without Ice or Snow, yea though it were carried at a Saddle-bow, and exposed to the Sun all the day.

SEt your wine in a vial of Glass, and place it in a Box made of wood, leather, or such like, about which vial place Salt-peter, and it will preserve it and keep it very fresh: this experiment is not a little commodious for those which are not near fresh waters, & whose dwellings are exposed to the Sun.

PROBLEM CXXVIII.

To make a Cement which lasteth as Marble, & resisteth air & water, without dis-joyning or uncementing.

TAke a quantity of strong and gluing Morter well beaten, mix with this as much new-flaked lime, & on it cast Oil-Olive, or Linseed-Oil, and it will be hard as Marble, being applied in time.

PROBLEM CXXIX.

How to melt Metal very quickly, yea in a Shell upon a little Fire.

MAke a bed upon a bed of Metal with powder of Sulphur, of Salt-peter, & Saw-dust alike; then put fire to the said powder with a burning Charcoal, and you shall see that the metal will dissolve incontinent, and be in a mass. This secret is most excellent, & hath been practised by the reverend Father Mercenno of the Order of the *Minimi*.

PROBLEM CXXX.

How to make Iron or Steel exceeding hard.

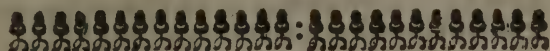
Quench your Blade or other Instrument seven times in the blood of a male hog mixt with Goose-grease, and at each time dry it at the fire before you wet it, and it will become exceeding hard and not brittle, which is not ordinary according to other temperings and quenchings of Iron: an experiment of small cost, often proved, and of great consequence for Armory, & warlike Negotiations

PROBLEM CXXXI.

To preserve Fire as long as you will, imitating the inextinguishable Fire of Vestals.

After you have extracted the burning spirit of the Salt of ψ , by the degrees of fire, as is required according to the Art of Chymistry, the fire being kindled of it self, break the Limbeck, & the Irons which are found at the bottom will flame & appear as burning coals, as soon as they feel the air; which if you promptly inclose in a vial of Glasse, & that you stop it exactly with some good lute; or to be more assured, it may be closed up with *Hermes* wax, for fear the air get in. Then will it keep more than 1000 years (as a man may say) yea at the bottom of the Sea; and opening it at the end of the time, as soon as it feels the air it takes fire, with which you may light a Match. This Secret merits to be travelled after, and put in practice, for that it is not common, & full of astonishment, seeing all kind of fire lasteth but as long as his matter lasteth, and there is no matter to be found that will so long indure.

Arri-



Artificial Fire-Works :

Or the manner of making
ROCKETS and BALLS of FIRE,
As well for the Water as the Air.

With the Composition of Stars, Golden-Rain,
Serpents, Lances, Wheels of Fire, and such-
like, Pleasant and Recreative.

Of the Composition for Rockets.



IN the making of Rockets, the chiefest thing to be regarded is the composition that they ought to be filled with ; forasmuch as that which is proper to Rockets which are of a less sort, is very improper to those which are of a more greater form ; for the fire being lighted in a great concave, which is filled with a quick Composition, burns with great violence ; contrarily, a weak composition being in a small concave, makes no effect. Therefore we shall here deliver in the first place Rules and Directions which may serve for the true composition or matter with which you may charge any Rocket, from Rockets which

are charged but with one ounce of Powder, unto great Rockets which require for their charge 10 pound of Powder, as followeth:

For Rockets of one ounce.

Unto each pound of good Musket Powder small beaten, put two ounces of Small-coal-dust, and with this composition charge the Rocket.

For Rockets of 2 or 3 ounces.

Unto every four ounces and a half of Powder-dust, add an ounce of Salt-peter, or to every four ounces of Powder-dust, add an ounce of Coal-dust.

For Rockets of 4 ounces.

Unto every pound of Powder-dust, add four ounces of Salt-peter, and one ounce of Coal-dust: but to have it more flow, unto every ten ounces of good powder-dust, add 3 ounces of Salt-peter, and 3 ounces of Coal-dust.

For Rockets of 5 or 6 ounces.

Unto every pound of Powder-dust add three ounces and an half of Salt-peter, and two ounces and an half of Coal-dust, as also an ounce of Sulphur, and an ounce of File-dust.

For Rockets of 7 or 8 ounces.

Unto every pound of Powder-dust add 4 ounces of Salt-peter, and 3 ounces of Sulphur.

Of Rockets of 10 or 12 ounces.

Unto the precedent composition add half an ounce of Sulphur, and it will be sufficient.

For Rockets of 14 or 15 ounces.

Unto every pound of Powder-dust add four ounces of Salt-peter, or Coal-dust $2\frac{1}{4}$ ounces, of Sulphur and File-dust $1\frac{1}{4}$ of an ounce.

For

For Rockets of 1 pound.

Unto every pound of Powder-dust add 3 ounces of Coal-dust, and 1 ounce of Sulphur.

For Rockets of 2 pound.

Unto every pound of Powder-dust add $9\frac{1}{2}$ ounces of Salt-peter, of Coal-dust $2\frac{1}{2}$ ounces, of File-dust $1\frac{1}{2}$ ounce, and of Sulphur $\frac{3}{4}$ of an ounce.

For Rockets of 3 pound.

Unto every pound of Salt-peter add 6 ounces of Coal-dust, and of Sulphur 4 ounces.

For Rockets of 4, 5, 6, or 7 pound.

Unto every pound of Salt-peter add 5 ounces of Cole-dust, and $2\frac{1}{2}$ ounces of Sulphur.

For Rockets of 8, 9, or 10 pound.

Unto every pound of Salt-peter add $5\frac{1}{2}$ ounces of Coal-dust, and of Sulphur $2\frac{1}{2}$ ounces.

Here note, That in all great Rockets there is no Powder put, because of the greatness of the fire which is lighted at once, which causeth too great a violence, therefore ought to be filled with a more weak composition.

Of the making of Rockets, and other Fire-works.

FOR the making of Rockets of sundry kinds, divers moulds are to be made, with their Rolling-pins, Breaths, Chargers, &c. as may be seen here in the figure. And having rolled a Case of Paper upon the Rolling-pin for your mould, fill it with the composition belonging to that mould, as before is delivered: now may you load it on the top with Serpents, Reports, Stars, or

264 Artificial Fire-Works.

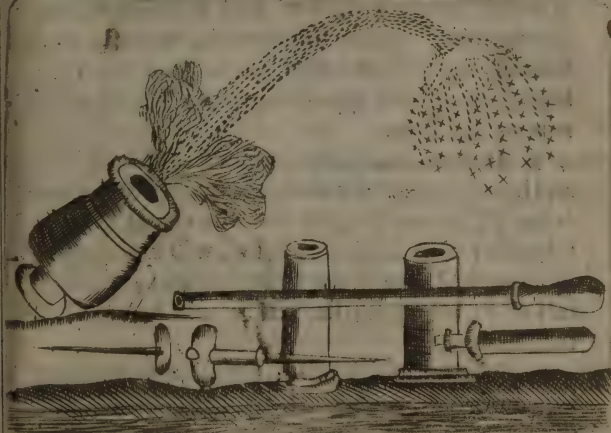
Golden Rain: The Serpents are made about the bigness of ones little finger, by rolling a little paper upon a small Stick, and then tying one end of it, and filling it with the mixt composition somewhat close, and then tying the other end. The Reports are made in their Paper-Cases, as the Serpents, but the Paper somewhat thicker to give the greater report. These are filled with grain-



Powder, or half-Powder and half Composition, and tying both ends close, they are finished. The best kind of Stars are made with this mixture following; unto every 4 ounces of Salt-peter add 2 ounces of Sulphur, and to it put one ounce of Powder-dust, and of this composition make your Stars, by putting a little of it within a small quantity

Artificial Fire-Works. 265

city of Towe; and then tying it up in the form of a Ball as great as an Hasel-Nut or a little Walnut, through which there must be drawn a little Primer to make it take fire. Touching the making of the Golden-Rain, that is nothing but filling of Quills with the composition of your Rockets somewhat hard. Now if the head of a



Rocket be loaded with a thousand of those Quills, its a goodly sight to see how pleasantly they spread themselves in the Air, and come down like streams of Gold much like the falling down of Snow, being agitated by some turbulent Wind.

Of Recreative FIRES.

1. **P**hiloftrates saith, That if Wine in a Platter be placed upon a Receiver of burning Coals, to exhale the spirit of it, and be inclosed within a Cupboard or such-like place, so that the Air may not go in nor out, and so being shut up for 30 years, he that shall open it, having a Wax Candle lighted, and shall put it into the Cupboard, there will appear unto him the figure of many clear Stars.

2. If *Aqua-vitæ* have Camphire dissolved in it, and be evaporated in a close Chamber, where there is but a Charcoal fire, the first that enters into the Chamber with a Candle lighted, will be extreamly astonished, for all the Chamber will seem to be full of Fire very subtil, but it will be of little continuance.

3. Candles which are deceitful are made of half Powder, covered over with Tallow, and the other half is made of clean Tallow or Wax, with an ordinary Week; this Candle being lighted, and the upper half consumed, the Powder will take fire, not without great noise and astonishment to those which are ignorant of the cause.

4. A dozen or twenty small Serpents placed secretly under a Candlestick that is indifferent big, which may have a hole pass through the Socket of it to the Candle, through which a piece of Primer may be placed, and setting a small Candle in the Socket to burn according to a time limited;

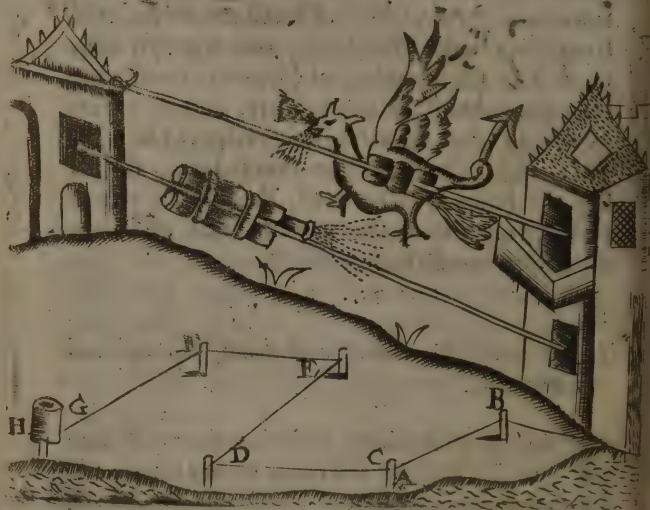
limited; which Candlestick may be set on a side-Table without suspicion to any; then when the Candle is burned, that it fires the Primer, that immediately will fire all the Serpents, which overthrowing the Candlestick will fly here and there, intermixing themselves, sometimes in the Air, sometimes in the Planching, one amongst another, like the crawling of Serpents, continuing for a pretty while in this posture, and in extinguishing every one will give his Report like a Pistol: This will not a little astonish some, thinking the house will be fired, though the whole powder together makes not an ounce, and hath no strength to do such an effect.

How to make Fire run up and down, forward and backward.

TAKE small Rockets, and place the tail of one to the head of the other upon a Cord, according to your fancy; as admit the Cord to be *A, B, C, D, E, F, G*; give fire to the Rocket at *A*, which will fly to *B*, which will come back again to *A*, and fire another at *C*, that will flie at *D*, which will fire another there, and fly to *E*, and that to *F*, and so from *F* to *G*, and at *G* may be placed a pot of Fire, viz. *GH*, which fired will make good sport, because the Serpents which are in it will variously intermix themselves in the air and upon the ground, and every one will extinguish with a report; and here may you note that upon the Rockets may be placed Fiery Dragons.

Com-

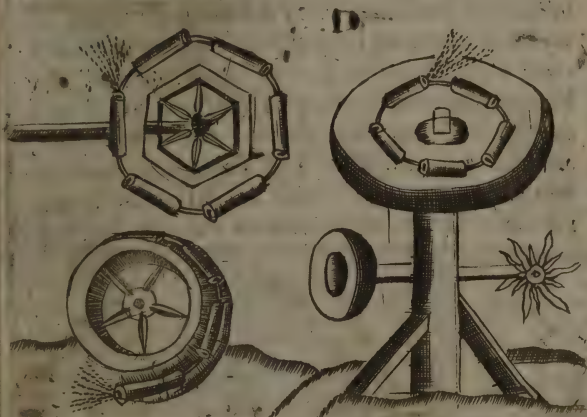
Combatants, or such-like, to meet one another, having Lights placed in the Concavity of their Bodies, which will give great grace to the Action.



How to make Wheels of Fire.

TAke a Hoop, and place two Laths acrofs one the other; upon the crossing of which make a hole, so that it may be placed upon a pin to turn easily, as the figure *Q* sheweth, upon the sides of which Hoop or round Circle place your Rockets, to which you may place Lances of Fire between each Rocket: let this Wheel be placed upon a Standard, as is here represented, and place a
piece

piece of Primer from one Lance to another, then give fire at *G*, which will fire *F*, that *E*, that will fire *D*, that *C*, and that will fire the Rocket at *A*; then immediately the Wheel will begin to move,



and represent unto the Spectators a Circle of changable Fire, and if Pots of Fire be tied to it, you will have fine sport in the turning of the Wheel, and casting out of the Serpents.

Of Night-Combatants.

CLubs, Targets, Faulchons, and Maces, charged with several Fires, do make your Night-Combatants, or are used to make place amongst a throng of People. The Clubs at the Ends are made like a round Pannier with small sticks filled with little Rockets in a spiral form, glued and so placed that they fire but one after another. The Maces are of divers fashions, some made oblong at

at the end : some made of a spiral form, but all made hollow, to put in several compositions, and are boared in divers places, which are for sundry Rockets and Lances of weak composition to be fired at pleasure. The Faulchons are made of wood in a bowing form, like the figure *A*, having their backs large to receive many Rockets, the head of one near the neck of another, glued and fastend well together, so that one being spent, another may be fired. The Targets are made of wooden thin boards, which are channeled in spiral Lines to contain Primer to fire the Rockets



one after another, which is all covered with thin covering of wood or pastboard, bored with holes spirally also ; which Rockets must be glued and made fast to the place of the Channel. Now if two
men

men, the one having a Target in his hand, and the other a Faulchon or Mace of Fire, shall begin to fight, it will appear very pleasant to the Spectators: for by the motion of fighting, the place will seem to be full of streams of Fire: and there may be adjoynd to each Target a Sun or a burning Comet with Lances of fire, which will make them more beautiful and resplendent in that action.

Of standing Fires.

Such as are used for Recreation, are *Collossus*, *Statues*, *Arches*, *Pyramides*, *Chariots*, *Chairs of Triumph*, and such-like, which may be accom-



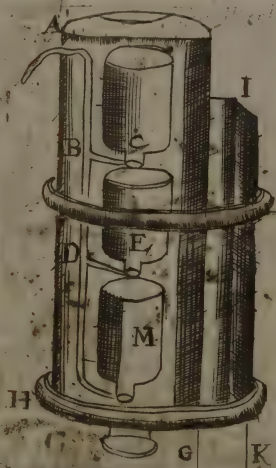
modated with Rockets of Fire, and beautified with sundry other artincial Fires, as Pots of Fire for the Air, which may cast forth several figures, Scutchions, Rockets of divers sorts, Stars, Crowns, Letters,

Letters, and such-like, the borders of which may be armed with sundry Lances of Fire, of small flying Rockets, with reports, flames, of small Birds of Cypres, Lanthorns of Fire, Candles of divers uses, and colours in burning, and whatsoever the fancy of an ingenious head may allude unto.

Of Pots of Fire for the Air, which are thrown out of one Case one after another, of a long continuance.

MAke a long Trunk, as *AG*, and by the side *AH*, let there be a Channel which may be fiered with slow primer or composition; then having charged the Trunk *AG*, with the Pots of Fire for the Air, at *IGEC*, and make the Trunk *AG* very fast unto a post, as *IK*, give fire at the top, as at *A*, which burning downwards will give fire to *C*, & so throw out that Pot in the Air, which being spent, in the mean time the fire will burn from *B* to *D*, and so fire *E*, and throw it out also in-

to the Air, and so all the rest one after another will be thrown out: and if the Pots of Fire for the Air which are cast out, be filled with divers Fire-works they

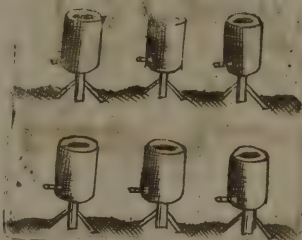


Artificial Fire-Works. 273

they will be so much the more pleasant to the Beholders. These Trunks of Fire do greatly adorn a Fire-work, and may conveniently be placed at each Angle of the whole Work.

Of Pots of Fire for the Ground.

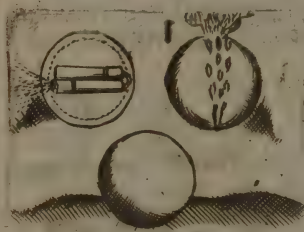
MAny Pots of Fire being fired together, do give a fine representation and recreation to the Spectators, and cause a wonderful shout amongst the common people who are standers by; for those Pots being filled with Balls of Fire and flying Serpents for the Air, they will so intermix one within another, in flying here and there a little above the ground, and giving such a volley of reports that the Air will rebound with their Noise, and the whole place be filled with sundry streams of pleasant fire; which Serpents will much occupy those about the place to defend themselves in their upper parts, when they will no less be busied by the Balls of Fire which seem to annoy their Feet.



Of Balls of Fire.

THese are very various, according to a mans fancy; some of which are made with very small Rockets, the head of one tied to the neck of
T another;

another: The Ball being made, may be covered over with Pitch, except the hole to give fire to it; this Ball will make fine sport amongst the standers by, which will take all a fire, and roll sometimes this way, sometimes that way, between the legs of those that are standers by, if they take not heed, for the motion will be very irregular;



and in the motion will cast forth several fires with reports. In the second kind there may be a Channel of Iron placed in divers places in spiral manner, against which may be placed

as many small Petards of Paper as possible may be, the Channel must be full of slow composition, and may be covered as the former, and made fit with his Rockets in the middle: This Ball may be shot out of a Mortar-Piece, or charged on the top of a Rocket: for in its motion it will fly here and there, and give many reports in the Air, because of the discharge of the Petards.

Of Fire upon the Water.

PLaces which are situated upon Rivers or great Ponds, are proper to make Recreative Fires on: and if it be required to make some of consequence, such may conveniently be made upon two Boats, upon which may be built two Beasts, Turrets, Pageants, Castles, or such-like, to receive

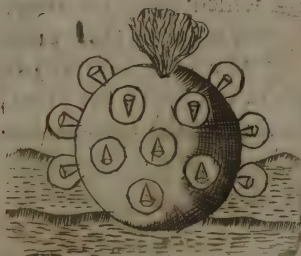
ceive or hold the diversity of Fire-Works that may be made within it, in which may play divers Fires, Petards, &c. and cast out many simple Granadoes, Balls of Fire to burn in the Water, Serpents, and other things; and often times these Boats in their incounters may hang one in another, that so the Combatants with the Targets and Maces may fight; which will give great content to the Eyes of those which are Lookers on, and in the conclusion fire one another, (for which end they were made: by which the dexterity of the one may be known in respect of the other, and the triumph and victory of the fight gotten.



Of Balls of Fire which move upon the Water.

THese may be made in form of a Ball stuffed with other little Balls, glued round about, and filled with composition for the Water, which

fiered will produce marvellous and admirable effects, for which there must be had little Cannons of white Iron, as the ends of small funnels; these Iron Cannons may be pierced in sundry places, to which holes, may be set small Balls full of composition, for the Water; which small Balls must be pierced deep and large, and covered with Pitch except the hole: in which hole must be first placed



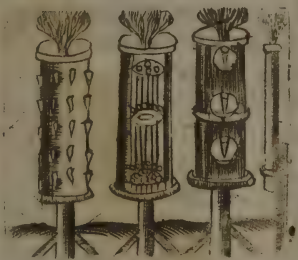
a little quantity of grain-powder, and the rest of the hole filled up with composition; and note further, that these Iron Cannons must be filled with a slow composition, but

such which is proper to burn in the Water: then must these Cannons with their small Balls be put so together that it may make a Globe, and the holes in the Cannons be answerable to the hollow Balls, and all covered over with Pitch and Tallow; afterwards pierce this Ball against the greatest Cannon (to which all the lesser should answer) unto the composition, then fire it, and when it begins to blow, throw it into the Water, so the fire coming to the holes will fire the grain-Powder, the which will cause the Balls to separate, and fly here and there, sometimes two at a time, sometimes three, sometime more, which will burn within the Water, with great astonishment and content to those which see it.

of

Of Lances of Fire.

STanding Lances of Fire are made commonly with hollow wood to contain sundry Petards or Rockets, as the figure here sheweth, by which it is easie to invent others, according to ones fancy. These Lances have wooden handles that so they may be fastened at some Post, so that they be not overthrown in the flying out of the Rockets or Petards: There are lesser sorts of Lances whose cases are of three or four foldings of Paper of a foot long, and about the bigness of ones finger, which are filled with a composition for Lances. But if these Lances be filled with a composition, then (unto every 4 ounces of powder add 2 ounces of Salt-peter, and unto that add r



ounce of Sulphur) it will make a Brick fire red before it be half spent, if the Lance be fiered and held to it: and if 20 such Lances were placed about a great Rocket, and shot to a House

or Ship, it would produce a mischievous effect.

How to shoot a Rocket Horizontal, or otherwise.

UNto the end of the Rocket place an Arrow which may not be too heavy, but instead of the feathers let that be of thin white Tin plate,

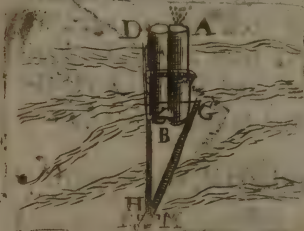


and place it upon a rest, as here you may see by the Figure, then give fire unto it, and you may see how serviceable it may be. To the head of such Rockets may be placed Petards,

Balls of Fire, Granadoes, &c. and so may be applied to War-like affairs.

How a Rocket burning in the Water for a certain time, at last shall fly up in the Air with an exceeding quickness.

TO do this, take two Rockets, the one equal to the other, and joyn them one unto another in the middle at *C*, in such sort that the fire may easily pass from one to another: it being thus done, tie the two Rockets at a Stick in *D*, and let it be so long and great, that it may make the



Rockets in the water hang, or lie upright, then take a packthread, and tie it at *G*, and let it come double about the stick *DM* at *H*, and at that point hang a Bullet of some

weight, as *K*, for then giving fire at *A*, it will burn to *B*, by a small Serpent filled there, and tied at the

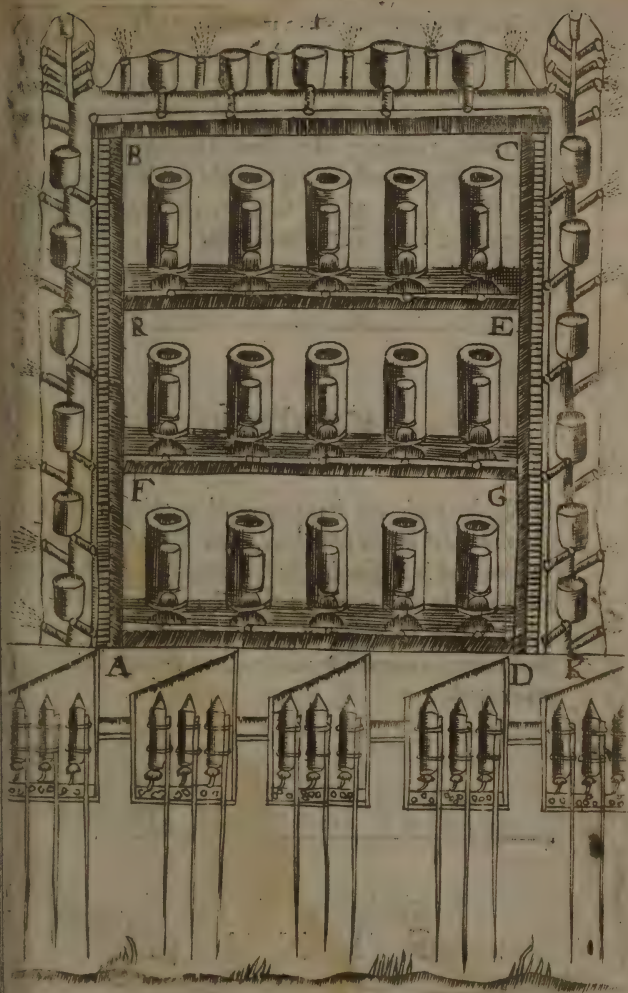
the end, and covered so that the Water injure it not, which will fire the Rocket *B D*, and so mounting quick out of the Water by the loose tying at *C*, and the Bullet at the pack-thread will leave the other Rocket in the Water, and so ascend like a Rocket in the Air, to the admiration of such as know not the secrecy.

Of the framing of the Parts of a Fire-Work together, that the several Works may fire one after another.

CAuse a Frame to be made, as *A B C D*, of two foot square every way, or thereabouts, (according to the quantity of your several works) then may you at each angle have a great Lance of Fire to stand, which may cast out Pots of Fire, as they consume: Upon the ledges *AB*, *BC*, and *CD*, may be placed small Lances of Fire, about the number of 30 or 60, some side-wise, and others upright; between these Lances may be placed Pots of Fire sloping outwards, but made very fast, and covered very close, that they chance not to fire before they should; then upon the ledges *RE*, *FG*, *HI*, and *AD*, may be placed your Soucisons, and behind all the Work may be set your Boxes of Rockets, in each of which you may place 6, 9, 12, or 20 small Rockets: Now give fire at *A*, (by help of a piece of Primer going from one Lance to another) all the Lances will instantly at once be lighted, and as soon as the Lance at *A* is consumed, it will fire the Channel which is made in the ledge of the frame, which runs under the Pots of Fire, and as the Fire goes along

burning, the Pots will be cast forth, and so the rank of Pots upon the sides of the frame *AB*, *BC*, and *CD*, being spent, the *Soucifons* will begin to play, being fiered also by a Channel which runs under them, upon the ledges *AD*, *HI*, *FG*, and *RE*, then when the *Soucifons* are spent upon the last ledge, *RE*, there may be a secret channel in the ledge *CD*, which may fire the Box of Rockets at *K*, & may fire all the rest one after another; which Boxes may be all charged with several Fire-works: for the Rockets of the first Box may be loaden with Serpents, the second with Stars, the third with Reports, the fourth with Golden-Rain, and the fifth with small flying Serpents; these mounting one after another, and flying to and fro, will much enlighten the Air in their ascending; but when these Rockets discharge themselves above, then will there be a most pleasant representation: for these Fires will dilate themselves in divers beautiful forms, some like the branching of Trees, others like Fountains of Water gliding in the Air, others like flashes of Lightning, others like the glittering of Stars, giving great contentment and delight to those which behold them: But if the work be furnished also with Balons, (which is the chiefest in recreative Fire-works) then shall you see ascending in the air but as it were only a quill of Fire, but once the Balon taking fire, the Air will seem more than 100 foot square full of crawling and flying Serpents, which will extinguish with a volley of more than 500 reports, and so fill the Air and Firmament with their rebounding clamour.

The



The making of which with many other rare and excellent Fire-Works, and other practises, not onely for Recreation, but also for Service; you may find in a Book intituled *Artificial Fire-Works*, made by Mr. *Malibaz* (a Master of his Knowledge) and are to be sold by *William Leak*, and *John Leak*, at the Crown in *Fleetstreet*, between the Two Temple-Gates.

Conclusion.

IN this Book we have omitted nothing that was material in the Original, but have abundantly augmented it in sundry Experiments. And though the Examinations are not so full and manifold, yet (by way of Brevity) we have expressed fully their Substance, to avoid Prolixity, and so pass by things reiterated.

F I N I S.

THE
DESCRIPTION and USE
OF THE
Double Horizontal
D Y A L.

WHEREBY,

Not onely the Hour of the Day is shewn,
but also the *Meridian Line* is found.

And most

Astronomical Questions

Which may be done by the GLOBE,
Are Resolved.

Whereunto is Added,

The Description of the General
Horological Ring.

Invented and Written by W.O.

L O N D O N :

Printed for *William Leak* and *John Leak*, at the Crown in
Fleetstreet, between the Two Temple-Gates. 1674.

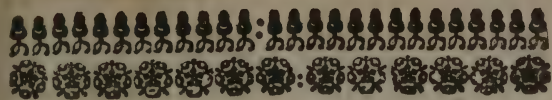


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THE
DESCRIPTION and USE
OF THE
Double Horizontal Dyal.



Here are upon the Plate two several Dyals. That which is outermost, is an ordinary Dyal, divided into hours and quarters, and every quarter into three parts, which are five minutes apiece : so that the whole hour is under-

stood to contain 60 minutes. And for this Dyal the shadow of the upper oblique or slanting edge of the Style or Cock doth serve.

The other Dyal which is within, is, *The Projection of the Upper Hemisphere upon the Plain of the Horizon* : The Horizon it self is understood to be the innermost circle of the Limb, and is divided on both sides from the points of East and West in-

to

2 The Description and Use of the

to degrees noted with 10, 20, 30, &c. as far as need requireth: And the centre of the Instrument is the *Zenith* or *Vertical point*.

Within the *Horizon*, the middle straight Line pointing *North* and *South*, upon which the Style standeth, is the *Meridian* or *Twelve a Clock Line*; and the other short arching Lines on both sides of it, are the *Hour-Lines*, distinguished accordingly by their figures; and are divided into quarters by the smaller Lines drawn between them, every quarter containing 15 minutes.

The two Arches which cross the *Hour-Lines*, meeting on both sides in the points of intersection of the Six a Clock Lines with the *Horizon*, are the two Semicircles of the *Ecliptick*, or annual circle of the Sun: the upper of which Arches serveth for the Summer half-year, and the lower for the Winter half-year, and therefore divided into 365 days, which are also distinguished into twelve months, with longer Lines, having their names set down: and into tenths and fifths with shorter Lines; and the rest of the days with pricks, as may plainly be seen in the Dial.

And this is for the ready finding out of the place of the Sun every day: and also for the shewing of the Sun's yearly Motion, because by this motion the Sun goeth round about the Heavens in the compass of a year, making the four parts or seasons thereof, namely, the *Spring* in that quarter of the *Ecliptick* which begins at the intersection on the East side of the Dial, and is therefore called, *The Vernal Intersection*. Then the *Summer* in that quarter of the *Ecliptick* which begins

Double horizontal Dial. 3

at the intersection with the *Meridian* in the highest point next the *Zenith*. After that, *Autumn* in that quarter of the *Ecliptick* which beginneth at the intersection on the West-side of the Dial, and is therefore called, *The Autumnal Intersection*. And lastly, the *Winter* in that quarter of the *Ecliptick* which beginneth at the intersection with the *Meridian* in the lowest point next the *Horizon*.

But besides this *Yearly Motion*, the Sun hath a *Diurnal* or *Daily Motion*, whereby it maketh day and night, with all the diversities and inequalities thereof: which is expressed by those other Circles drawn cross the Hour-lines; the middlemost whereof, being grosser than the rest, meeting with the *Ecliptick* in the points of the *Vernal* and *Autumnal Intersections*, is the *Equinoctial*; and the rest on both sides of it are called the *Parallels*, or *Diurnal Arch of the Sun*, the two outermost whereof are the *Tropicks*, because in them the Sun hath his furthest *Digression* or *Declination* from the *Equinoctial*, which is degrees $23\frac{1}{2}$, and thence beginneth again to return towards the *Equinoctial*. The upper of the two *Tropicks* in this our Northern Hemisphere, is the *Tropick of Cancer*, and the Sun being in it is highest into the North, making the longest day of Summer: And the lower next the *Horizon* is the *Tropick of Capricorn*; and the Sun being in it, is lowest into the South, making the shortest day of Winter.

Between the two *Tropicks* and the *Equinoctial*, infinite such *Parallel Circles* are understood to be contained: for the Sun in what point soever of the

4 The Description and Use of the

the *Ecliptick* it is carried, describeth by his *Station* a Circle parallel to the *Equinoctial*; yet those *Parallels* which are in the Instrument, though drawn but to every second degree of *Declination*, may be sufficient to direct the Eye in imagining and tracing out through every day of the whole year in the *Ecliptick* a proper Circle which may be the *Diurnal Arch* of the Sun for that Day: For upon the right estimation of that imaginary Parallel doth the manifold use of this Instrument especially rely, because the true place of the Sun all that day is in some part or point of that Circle. Wherefore for the better conceiving and bearing in mind thereof, every fifth Parallel is herein made a little grosser than the rest.

For this inner Dyal serveth the shadow of the upright edge of the Style, which I therefore call the Upright Shadow.

And thus, By the Eye and View onely to behold and comprehend the Course of the Sun throughout the whole Year, both for his Annual and Diurnal Motion, may be the first Use of this Instrument.

USE II.

To find the Declination of the Sun every Day.

Look the day of the month proposed in the *Ecliptick*, and mark how many degrees the prick shewing that day is distant from the *Equinoctial*, either on the Summer or Winter side, viz. North or South.

Example

Double Horizontal Dial. 5

Example 1. What will the *Declination* of the Sun be upon the 11th day of *August*? Look the 11th day of *August*, and you shall find it in the 6th circle above the Equinoctial: Now because each Parallel standeth (as hath been said before) for two degrees, the Sun shall that day decline Northwards 12 degrees.

Example 2. What Declination hath the Sun upon the 24 day of *March*? Look the 24 day of *March*, and you shall find it between the second and third Northern Parallels, as it were an half and one fifth part of that distance from the second: Reckon therefore four degrees for the two circles, and one degree for the half space: So shall the Suns Declination be five degrees, and about one fifth part of a degree Northward, that same day.

Example 3. What Declination hath the Sun upon the 13 day of *November*? Look the 13 day of *November*, and you shall find it below the Equinoctial ten Parallels, and about one quarter, which is 20 degrees and an half Southward. So much is the Declination. And according to these Examples judge of all the rest.

USE III.

To find the Diurnal Arch or Circle of the Suns course every day.

The Sun every day by his motion (as hath been said) describeth a Circle parallel to the Equinoctial, which is either one of the Circles in the Dy-

6 The Description and Use of the

al, or somewhere between two of them. First therefore seek the day of the month, and if it fall upon one of those Parallels, that is the Circle of the Suns course that same day: But if it fall between any two of the Parallels, imagine in your mind, and estimate with your eye, another parallel through that point between those two parallels, keeping still the same distance from each of them.

As in the first of the three former Examples, The Circle of the Suns course upon *August 11*. shall be the very sixth Circle above the Equinoctial towards the Centre.

In example 2. The Circle of the Suns course upon the 24 of *March* shall be an imaginary Circle between the second and third Parallels, still keeping an half of that space, and one fifth part more of the rest, from the second.

In example 3. The Circle of the Suns course upon the 13 of *Novemb*, shall be an imaginary Circle between the 10th and 11th Parallels below the Equinoctial, still keeping one quarter of that space from the tenth.

USE IV.

To find the Rising and Setting of the Sun every day.

Seek out (as was last shewed) the imaginary Circle or Parallel of the Suns course for that day, and mark the point where it meeteth with the Horizon, both on the *East* and *West* sides, for that is the very point of the Suns Rising and Setting that

Double Horizontal Dial. 7

that same day, and the hour-lines which are on both sides of it, by proportioning the distance reasonably, according to 15 minutes for the quarter of the hour, will shew the hour of the Suns Rising on the East side, and the Suns Setting on the West side.

USE V.

To know the reason and manner of the Increasing and Decreasing of the Days and Nights throughout the whole Year.

When the Sun is in the Equinoctial, it riseth and setteth at 6 a clock : for in the instrument the intersection of the Equinoctial and the Ecliptick with the Horizon, is in the 6 a clock Circle on both sides. But if the Sun be out of the Equinoctial, declining toward the North, the intersections of the Parallel of the Sun with the Horizon is before 6 in the morning, and after 6 in the evening : and the Diurnal Arch greater than 12 hours, and so much more great, the greater the Northern Declination is. Again, if the Sun be declining toward the South, the intersections of the Parallel of the Sun with the Horizon is after 6 in the morning, and before 6 in the evening : and the Diurnal Arch lesser then 12 hours ; and by so much lesser, the greater the Southern Declination is.

And in those places of the Ecliptick in which the Sun most speedily changeth his Declination, the length also of the day is most altered : and

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where the Ecliptick goeth most parallel to the Equinoctial changing the Declination, but little altered. As for example : When the Sun is near unto the Equinoctial on both sides, the days increase and also decrease suddenly and apace ; because in those places the Ecliptick inclineth to the Equinoctial in a manner like a straight Line, making sensible declination. Again, when the Sun is near his greatest declination, as in the height of Summer, and the depth of Winter, the days keep for a good time as it were at one stay, because in those places the Ecliptick is in a manner parallel to the Equinoctial, the length of the day also is but little, scarce altering the declination : And because in those two times of the year the Sun standeth as it were still at one declination, they are called the *Summer Solstice*, and *Winter-Solstice*. And in the mean space the nearer every place is to the Equinoctial, the greater is the diversity of days.

Wherefore we may hereby plainly see that the common received opinion, that in every month the days do equally increase, is erroneous.

Also we may see that in Parallels equally distant from the Equinoctial, the day on the one side is equal to the night on the other side.

USE VI.

To find how far the Sun Riseth and Setteth from the true East and West Points, which is called the Suns Amplitude Oriive and Occasive.

Seek out (as was shewed in Use III.) the imaginary

Double Horizontal Dial. 9

inary Circle or Parallel of the Suns course, and the points of that Circle in the Horizon, on the East and West sides cutteth the degree of the *Amplitude Ortive*, and *Occasive*.

USE VII.

To find the Length of every Day and Night.

Double the hour of the Suns setting, and you shall have the length of the Day; and double the hour of the Suns rising, and you shall have the length of the Night.

USE VIII.

To find the true place of the Sun upon the Dial, that is, the point of the Instrument which answereth to the place of the Sun in the Heavens at any time, which is the ground of all the Questions following.

If the Dial be fixed upon a Post, look what a clock it is by the outward Dial, that is, look what hour and part of the hour the shadow of the slanting edge of the Style sheweth in the outward Limb. Then behold the shadow of the upright edge, and mark what point thereof is upon that very hour and part in the inner Dial among the Parallels, that point is the true place of the Sun at the same instant.

If the Dial be not fixed, and you have a Meridian Line noted in any Window where the Sun shineth: place the Meridian of your Dial upon the Meridian Line given, so that the top of the

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Style may point into the North, and so the Dyal is as it were fixed, wherefore by the former Rule you may find the place of the Sun upon it.

If the Dyal be not fixed, neither you have a Meridian Line, but you know the true hour of the day exactly: hold the Dyal even and parallel to the Horizon, moving it till the slanting edge of the Style cast his shadow justly upon the time or hour given; for then the Dyal is truly placed, as upon a post. Seek therefore what point of the upright shadow falleth upon that very hour, and there is the place of the Sun.

But if your Dyal be loose, and you know neither the Meridian nor the time of the day; First, by the day of the month in the Ecliptick, find the Suns Parallel or Diurnal Arch for that day, then holding the Dyal level to the Horizon, move it every way until the slanting shadow of the Style in the outward Limb, and the upright shadow in the Suns Diurnal Arch, both shew the very same hour and minute; for that very point of the Suns Parallel which the upright shadow cutteth, is the true place of the Sun on the Dyal at that present.

But note that by reason of the thicknes of the Style, and the bluntness of the angle of the upright edge, the Sun cannot come unto that edge for some space before and after noon. And so during the time that the Sun shineth not on that upright edge the place of the Sun in the Dyal cannot be found. Wherefore they that make this kind of Double Dyal, are to be careful to file the upright edge of the Style as thin and sharp as possible may be.

That which hath here been taught concerning the

Double horizontal Dyal. II

the finding out the Suns true place in the Dyal, ought perfectly to be understood, that it may be readily and dexterously practised, for upon the true performance thereof dependeth all that followeth.

USE IX.

To find the Hour of the Day.

If the Dyal be fastened upon a Post, the hour by the outward Dyal or Limb, is known of every one, and the upright shadow in the Suns Parallel or Diurnal Arch will also shew the very same hour.

But if the Dyal be loose, either hold it or set it parallel to the Horizon, with the Style pointing into the North, and move it gently every way, until the hour shewed in both Dyals exactly agree; or which is all one, find out the true place of the Sun upon the Dyal, as was taught in the former question, for that point among the hour-lines sheweth the hour of the day.

USE X.

To find out the Meridian, and other points of the Compass.

First you must seek the true hour of the day (by the last question) for in that situation the Meridian of the Dyal standeth directly North and South: and the East pointeth into the East, and the West into the West, and the rest of the points may be given by allowing degrees $11\frac{1}{4}$ unto every point of the Compass.

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USE

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USE XI.

To find out the Azimuth of the Sun, that is, the distance of the Vertical Circle, in which the Sun is at that present from the Meridian.

Set your Dyal upon any plain or flat, which is parallel to the Horizon, with the Meridian pointing directly North or South, as was last shewed: then follow with your Eye the upright shadow in a straight Line, till it cutteth the Horizon: for the degree in which the point of intersection is, shall shew how far the Suns *Azimuth* is distant from the East and West points, and the Complement thereof unto 90, shall give the distance thereof from the Meridian.

USE XII.

To find out the Declination of any Wall upon which the Sun shineth; that is, how far that Wall swereth from the North or South, either Eastward or Westward.

Take a board, having one straight edge, and a Line stricken perpendicular upon it; apply the straight edge unto the Wall at what time the Sun shineth upon it, holding the board parallel to the Horizon: Set the Dyal thereon, and move it gently every way, until the same hour and minute be shewed in both Dyals, and so let it stand: then if the Dyal have one of the sides parallel to the Meridian strike a Line along that side upon the board

at the point where the crossing

Double Horizontal Dyal. 13

crossing the perpendicular, or else with a Bodkin make a point upon the board, at each end of the Meridian, and taking away the instrument from the board, and the board from the wall, lay a Ruler to those two points, and draw a line crossing the perpendicular: for the angle which that line maketh with the perpendicular, is the angle of the declination of the Wall. And if it be a right angle, the wall is exactly east or west: but if that line be parallel to the perpendicular, the wall is direct north or south, without any declination at all.

You may also find out the declination of a wall if the Dyal be fixed on a Post not far from that wall, in this manner: Your board being applied to the Wall, as was shewed, hang up a thread with a plummet, so that the shadow of the thread may upon the board cross the perpendicular line, make two pricks in the shadow, and run instantly to the Dyal, and look the horizontal distance of the Suns Azimuth or upright shadow from the Meridian. Then through the two pricks draw a line crossing the perpendicular: and upon the point of the intersection make a Circle equal to the Horizon of your Instrument, in which Circle you shall from the line through the two pricks measure the Horizontal Distance of the Upright Shadow or Azimuth from the Meridian, that way toward which the Meridian is: draw a line out of the centre to the end of that Arch measured: and the angle which this last line maketh with the perpendicular, shall be equal to the declination of the wall.

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USE XIII.

How to place the Dial upon a Post without any other Direction, but it self.

Set the Dial upon the Post, with the Stile into the North, as near as you can guess: then move it this way and that way, till the same hour and minute be shewed, both in the inward and outward Dials by the several shadows, as hath been already taught, for then the Dial standeth in its truest situation; wherefore let it be nailed down in that very place.

USE XIV.

To find the height of the Sun at high noon every day.

Seek out the Diurnal Arch or Parallel of the Suns course for that day, (by Use III.) and with a pair of Compasses, setting one foot in the centre, and the other in the point of intersection of that Parallel with the Meridian, apply that same distance unto the Semidiameter divided: for that measure shall therein shew the degree of the Suns altitude above the Horizon that day at high noon.

USE XV.

To find the height of the Sun at any hour or time of the day.

Seek out the Diurnal Arch, or Parallel of the Suns course for that day: and mark what point
of

Double horizontal Dial. 15

of it is in the very hour and minute proposed. And with a pair of Compasses, setting one foot in the centre, and the other in that point of the Parallel, apply the same distance upon the Semidiameter divided: for that measure shall shew the degree of the Suns altitude above the Horizon at that time.

And by this means you may finde the height of the Sun above the horizon at every hour throughout the whole year, for the making of Rings and Cylinders, and other Instruments, which are used to shew the hour of the day.

USE XVI.

The height of the Sun being given, to find out the hour, or what it is a Clock.

This is the converse of the former: Seek therefore in the Semidiameter divided, the height of the Sun given: and with a pair of Compasses, setting one foot in the centre, and the other at that height, apply the same distance unto the Diurnal Arch or Parallel of the Sun for that day: for that point of the Diurnal Arch upon which that same distance lights, is the true place of the Sun upon the Dial; and sheweth among the hour-lines the true time of the day.

USE XVII.

Considerations for using the Instrument in the night.

In such questions as concern the night, or the time

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time before Sun-rising and after Sun-setting, the Instrument representeth the lower Hemisphere, wherein the Southern Pole is elevated. And therefore the Parallels which are above the Æquinoctial towards the centre, shall be for the Southern or Winter-Parallels: and those beneath the Equinoctial for the Northern or Summer-Parallels; and the East shall be accounted for West, and the West for East; altogether contrary to that which was before, when the Instrument represented the upper Hemisphere.

USE XVIII.

To find how many degrees the Sun is under the Horizon at any time of the night.

Seek the Declination of the Sun for the day proposed, (by Use II.) and at the same declination the contrary side, imagine a Parallel for the Sun that night, and mark what point of it is in the very hour and minute proposed: And with a pair of Compasses, setting one foot in the Centre, and the other in that point of the Parallel, apply that same distance unto the Semidiameter divided: for that measure shall shew the degree of the Suns depression below the Horizon at that time.

USE XIX.

To find out the length of the Crepusculum, or Twy-light every day.

Seek the declination of the Sun for the day proposed

Double Horizontal Dial. 17

posed, (by Use II.) And at the same declination on the contrary side, imagine a Parallel for the Sun that night : And with a pair of Compasses, setting one foot in the Centre, and the other at 72 degrees upon the semidiameter divided, apply that same distance unto the Suns Nocturnal Parallel : for that point of the Parallel upon which that same distance shall light, sheweth among the hour-lines the beginning of the Twilight in the morning, or the end of the Twilight in the evening.

USE XX.

If the day of the month be not known, to find it out by the Dial.

For the working of this Question, either the Dial must be fixed rightly on a Post, or else you must have a true Meridian Line drawn in some Window where the Sun shineth ; wherefore supposing the Dial to be justly set, either upon the Post, or upon the Meridian, Look what a clock it is by the outward Dial, and observe what point of the upright shadow falleth upon the very same minute in the inner Dial, and through that same point imagine a Parallel circle for the Suns course, that Imaginary Circle in the Ecliptick shall cut the day of the month.

Of the General Horological Ring.

I. *The Description of it.*

THIS Instrument serveth as a Dial to find the hour of the day, not in one place onely (as the most part of Dyals do) but generally in all Countreys lying North of the Equinoctial; and therefore I call it, *The General Horological Ring.*

It consisteth of two Brazen Circles, a Diameter, and a little Ring to hang it by.

The two Circles are so made, that though they are to be set at right angles when you use the Instrument; yet for more convenient carrying, they may be one folded into the other.

The lesser of the two Circles is for the Equinoctial, having in the midst of the inner side or thickness a line round it, which is the true Equinoctial Circle, divided into twice 12 hours, from the two opposite points in which it is fastened within the greater.

The greater and outer of the two Circles is the Meridian: One quarter whereof, beginning at one of the points in which the Equinoctial is hung, is divided into 90 degrees.

The Diameter is fastened to the Meridian in two opposite points or poles, one of them being the very end of the Quadrant, and is the North Pole: Wherefore it is perpendicular to the Equinoctial, having his due position. The Diameter is broad, and slit in the middle, and about the slit on both sides are the months and days of the year.

And

Of the General Porological Ring. 19

And within this slit is a little sliding Plate pierced through with a small hole: which hole in the motion of it, while it is applied to the days of the year, representeth the Axis of the World.

The little Ring whereby the Instrument hangeth, is made to slip up and down along the *Quadrant*: that so by help of a little Tooth annexed, the Instrument may be rectified to any Elevation of the Pole.

II. *The Use of it.*

IN using this Instrument, 1. The tooth of the little Ring must carefully be set to the height of the Pole in the *Quadrant*, for the place wherein you are.

2. The hole of the sliding plate within the slit, must be brought exactly to the day of the month.

3. The *Equinoctial* is to be drawn out, and by means of the two studs in the Meridian staying it, it is to be set perpendicular thereto.

4. Guess as near as you can at the hour, and turn the hole of the little Plate toward it.

Lastly, Hold the *Instrument* up by the little *Ring* that it may hang freely with the *North Pole* thereof toward the North, and move it gently this way and that way, till the beams of the Sun shining thorow that hole, fall upon that middle line within the *Equinoctial*: for there shall be the hour of the day: And the Meridian of the Instrument shall hang directly North and South.

This or any other Mathematical Instrument either in Silver, Brass, or Wood, are exactly made by Hilkiah Bedford, in Fleetstreet, near Fetter-Lane End.

F I N I S.

Of the Oriental Topological

And again this is a little sliding Plate
through which a small hole in the
motion of it, while it is applied to the day of the
year: perpendicular the Axis of the World.
The little Ring whereby the Instrument hang-
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tine: that to be help of a little Tooth annexed
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IN BOOK 2.

In using this Instrument, The tooth of the
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turn the hole of the little Plate toward it.
Lastly Hold the Instrument up by the little Ring
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toward the North, and move it gently the way
and that way, till the beams of the Sun shining
through that hole fall upon that middle line which
in the Equinoctial: for there shall be the hour of
the day: And the Meridian be the Instrument
standing exactly North and South.

And when you have the Instrument set in such
a place, that the beams of the Sun may be seen
falling on the middle line, then you may know
the hour of the day.

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